Series II, Volume 4 June 18, 1959 Number 5

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

INCLUDING THE

PROGRAMME OF THE

1959 SUMMER MEETING IN THE EAST

AT

MILWAUKEE, WISCONSIN

June 18, 19, and 20

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June 18, 1959 Series II, Vol. 4, No. 5

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

1959 Summer Meeting in the East, June 18–20, 1959

THE 1959 June meeting of The American Physical Society, being the **1959 Summer Meeting in the East,** will be held at Milwaukee, Wisconsin, in the buildings of Marquette University, on Thursday, Friday, and Saturday, June 18, 19, and 20. This will be the first meeting which the Society will have held in Milwaukee for quite a considerable time, if not indeed altogether: it is possible that the Society may have joined in a meeting of the American Association for the Advancement of Science in that city, long ago. As usual, this will be the major meeting of our yearly calendar for our Division of Electron Physics. There will also be a symposium on the Philosophy of Science in which our host institution will be represented, and in other fields there will be invited papers mainly from the University of Wisconsin. Our Local Committee is headed by E. D. Berners; to Father L. W. Friedrich, S. J., we owe the invitation to hold this meeting at Marquette. This Committee has been extraordinarily good at preparing for the pleasures of our members as well as for their duties. Turn to pages 341 and 342 of this Bulletin, fill out and mail the various forms there provided to enable them to gratify you and your ladies: otherwise you will frustrate them and yourselves.

Milwaukee is accessible by rail over the Chicago & Northwestern, the Milwaukee Road and the Chicago, North Shore & Milwaukee electric line which last has hourly departures from the Loop (Adams and Wabash) in Chicago. From the Northwestern station, buses numbered 12 and 23 will convey you directly to the campus (at 12th and Wisconsin) in 10 minutes. From the Milwaukee Road and North Shore stations you walk one block northward and take buses 12, 23, or 30 westbound. Taxis can do either distance in 5 to 10 minutes. The airport is 40 minutes away by taxi. Those who drive to Milwaukee and wish to cross Lake Michigan, a six-hour voyage, may embark at Muskegon (Michigan) in the "Milwaukee Clipper" at 8 A.M. or 11:55 P.M. on June 17 or 4 P.M. on June 18; in the other direction they may sail from Milwaukee at 10 P.M. on June 20; all these times are given in Eastern Standard Time which equals the Central Daylight Saving Time that prevails in Milwaukee. Other routes from the East and the South give the motorist the opportunity of visiting Chicago, but if anyone wants to miss this he can detour around Chicago by means of the Tri-State Tollway.

Dormitory accommodations kindly made available by Marquette University for this meeting are described on page 341. To what is printed there is added that the "units" in Bonifas Hall are two-room suites with bath which can accommodate, at most, a couple with one child; and that a very few rooms at Schroeder Hall are singles with private bath at $6. *All reservations for the dormitories are to be made by use of the form on page 341.*

Hotel accommodations. Rooms have been set aside at the Knights Tower Hotel (singles $5.50 to $6, doubles $7 to $9) and the Wisconsin Hotel (singles $5.75 to $6.50, doubles with double beds $7.50 to $9, twin beds $11 and $12). Of these hotels the former is two blocks from the campus, the latter ten: "to reach the Marquette campus from the Wisconsin Hotel by bus, walk south to Wisconsin Avenue, board a westbound #30 bus between 3rd and 4th Streets, get off at 12th or 14th Street." Write to the hotel of your choice for your reservation, and *mention that you are coming to attend the meeting of the American Physical Society.*

Registration. On Wednesday, June 17 (day before the meeting) the registration desk will be functioning from 4 P.M. to 9 P.M. in the lounge of the ground floor of Schroeder Hall, which is at 725 North 13th Street. During the days of the meeting the registration desk will be in Room 103 in the Science Building, which is at 1217 West Wisconsin Avenue. Dinner tickets will be sold at the desk, and there will be blackboards for notice of messages and other announcements. The registration fee will be one dollar.

A Symposium on the Philosophy of Science, and specifically on *The Nature of Physical "Knowledge,"* has been organized through the joint efforts of Father L. W. Friedrich, and Henry Margenau, and in its programme will be found distinguished speakers to a number unusual even in our Society. It is set for Friday. In the morning the speakers are to be P. W. Bridgman, Philipp Frank, Henry Margenau, and George Klubertanz. In the afternoon the programme begins with a paper by A. Landé, and other sessions of the same afternoon are scheduled to begin only after it is over. The Symposium will be concluded by prearranged discussion and by general discussion.

Invited papers of our Division of Electron Physics are scheduled on Thursday afternoon, Friday afternoon, and Saturday afternoon. Those of Friday are grouped under the collective caption "Collision Processes" and those of Saturday under "Optical Pumping."

Most but not all of the **invited speakers on the general programme** are of the University of Wisconsin at Madison. The invited papers of this category are distributed among the sessions according to their topics.

Sixty-one contributed papers are distributed among nine sessions. It is an advantage of our smaller meetings that no session is wearisomely long.

A **cocktail hour** beginning at 6:00 P.M. will precede the banquet and comes to us through the courtesy of A-C Spark Plug, Electronics Division of General Motors, Milwaukee.

The **banquet of the Society** will be held on Friday evening in Brooks Memorial Union of Marquette University. This is one of the occasions on which we have to give a guarantee of attendance in advance of the opening of the meeting, and so we plead with our members to fill in and mail the appropriate form on page 342 of this Bulletin. Note that the form gives you the option of ordering tenderloin and baked whitefish (the latter a specialty of the region), and you must express your choice. The price will be four dollars. The after-dinner speakers will be P. W. Bridgman and A. Landé.

Delectable invitation. "Two of the local brewing companies have invited us to attend what might be called informal symposia on the Thursday evening. The invitation includes the ladies. The Miller Brewing Company will conduct a tour of its plant, after which beer, cheese and crackers will be served in the Stein Hall of the Miller Inn. There will be ample time to enjoy these Wisconsin products and to talk to others on the tour. The Schlitz Brewing Company will serve beer, pretzels and potato chips at its Hospitality House from 8 to 11. They cannot give us a tour of their plant, but the Hospitality House like the Miller Inn will provide an ideal atmosphere for relaxation, conversation, discussion or any combination thereof." Buses will leave Walter Schroeder Hall at 7:30; there will be a small charge for the ride. These gracious entertainments are available only to those who reserve in advance, for the capacity of each is limited, and the companies must know by Wednesday evening, June 17, how many are accepting. Use the form on page 342, and use it soon!

Ladies' Programme. "The ladies are invited to be the guests of the Marquette University Physics Department at a get-acquainted tea to be held in the Père Marquette Room in Brooks Memorial Union on Thursday from two to four in the afternoon, and also on a bus tour of Milwaukee's County Park system on Friday, June 19, morning and afternoon. On Friday there will be luncheon in the pavilion of lovely Jacobus Park, after which the tour will continue through Whitnall Park with its unique botanical display. The ladies will be returned to the city with plenty of time in which to prepare for the pre-banquet cocktail-party." Here again you are requested to make the necessary reservations in advance for your ladies by using the appropriate form on page 342. Children are welcome, but our hosts would like to know the number and their ages.

Post-deadline ten-minute papers, pertaining to very recent achievements of very special significance, will be considered for admission to the programme if the abstracts are received at the office of the Society not later than Friday, June 13. The titles of such papers as may be accepted will be written on a blackboard near the main registration desk. See the blackboard for the places and hours of presentation.

Prospective meetings and deadlines of the Society are listed on page 339 of this Bulletin, and on page 330 appears a preliminary announcement of the 1959 Summer Meeting in the West (at Honolulu). Listed here also are topical conferences (see page 302 of the April issue of this Bulletin).

Instructions for the preparation of abstracts are printed on page 339 of this Bulletin. It is prudent not to send in an abstract without re-reading the latest version of this paragraph.

Manuscripts of the talks given at our meetings are not sent to the office of the Society, and the office does not know where or when (if ever) fuller versions of the contents of abstracts will be published. Write to the authors for such information.

Errata pertaining to abstracts in this issue will be published in a later issue of this Bulletin if received not later than Monday, June 23, by Miss Ruth Bryans, American Institute of Physics, 335 East 45 Street, New York 17, New York. Do not send in the abstract with erasures and corrections. Write out your corrections in the form "Instead of . . . read . . ."; add nothing.

KARL K. DARROW, *Secretary*
American Physical Society
Columbia University
New York 27, New York

EPITOME OF THE 1959 MILWAUKEE MEETING

(Personal names are those of invited speakers.)

Thursday Morning

10:30 A. Magnetism and Ferroelectricity; R. C. Miller. Science Building 100.

10:30 B. Electron Physics I, including Phenomena in Gases. Science Building 200.

10:30 C. Nuclear theory. Science Building 300.

Thursday Afternoon

2:00 E. Dexter, Feher; Semiconductors. Science Building 100.

2:00 F. Division of Electron Physics: Chamberlain, Winckler, Lewis. Science Building 200.

2:00 G. Barschall; Halbert; Nuclear Physics I (Nuclear Reactions). Science Building 300.

Friday Morning

10:00 L. Electron Physics II: Electron Emission from Metals. Science Building 100.

10:00 M. Symposium on the Nature of Physical "Knowledge": Bridgman, Frank, Margenau, Klubertanz. Medical School.

Friday Afternoon

2:00 N. Symposium on the Nature of Physical "Knowledge," *continued:* Lande, discussion. Medical School.

2:45 P. Camerina; Nuclear Physics II. Science Building 200.

2:45 R. Symposium of the Division of Electron Physics: Collision Processes: Branscomb, Fite, Schulz. Science Building 100.

Saturday Morning

10:00 S. Symposium of the Division of Electron Physics: Optical Pumping: Kastler, Beaty, Dehmelt. Medical School.

10:00 T. Walker; Apparatus of Nuclear Physics; Magnetic Resonance. Science Building 100.

10:00 U. E. E. Miller, Anderson; General Physics. Science Building 200.

Friday Evening

5:00 Cocktail hour. Brooks Memorial Union.

7:00 Banquet of the American Physical Society. Brooks Memorial Union.

PROGRAMME

THURSDAY MORNING AT 10:30

Science Building 100

(W. F. BROWN, JR. presiding)

Magnetism and Ferroelectricity

A1. Quantum Theory of Transport in a Magnetic Field.* P. N. ARGYRES, *MIT.*—It is pointed out that previous theories of Lifshitz and the author on the quantum theory of electrical conduction in a magnetic field that take into account the quantization of the electron orbits are deficient in that they neglect terms in the transport equation that describe the effect of the electric field on the scattering. These terms are as important for the calculation of the current as the other terms that are kept. In this theory, the elements of the steady-state density matrix are found, on the basis of a procedure analogous to that of Kohn and Luttinger, to obey a transport equation, in which the scattering matrix is identical to that found by the author previously on the basis of time-dependent perturbation theory. New "driving" terms are, however, present that describe the acceleration due to electric field and its influence on the scattering. This transport equation is valid for arbitrary values of $\omega_0\tau$. It is found that for $\hbar\omega_0 \gg kT$ the usual classical result obtains. For $\hbar\omega_0 \lesssim kT$ quantum effects appear, which for the special case of $\omega_0\tau \gg 1$, are identical to those surmised by Titeica and others, and recently justified rigorously by Kubo and others.

* The work reported in this paper was performed by Lincoln Laboratory, a center for research operated by MIT with the joint support of the U. S. Army, Navy, and Air Force.

A2. Transient Response of Magnetic Alloys above 500°C.* G. E. LYNN AND M. LAURIENTE, *Westinghouse Air Arm.*—An anomalous transient response has been observed at temperatures between 500°C and 600°C for a toroidally wound tape core of a 49Co-2V-Fe alloy when tested with a constant-current flux-reset core tester. This type of tester excites the test core through an asymmetrical minor dynamic hysteresis loop by means of a unidirectional half-sinusoid of current. By applying a dc mmf (usually called reset mmf), in opposition to the mmf produced by the excitation pulse, the core can be operated over a different minor loop. This test, designed to simulate the action of a half-wave self-saturating magnetic amplifier is described in detail in many papers in the literature of the American Institute of Electrical Engineers. At temperatures 500°C and above, several minutes were required for a steady-state flux change to be established after a step change of reset mmf. This time delay is in strong contrast to the response of either alloy measured at room temperature. For the latter cases, a steady-state flux change is established within one cycle of excitation frequency.

* Work supported in part by Electronic Components Laboratory of the Wright Air Development Center.

A3. Strong Field Magnetization and Approach to Magnetic Saturation of Praseodymium Metal. WARREN E. HENRY, *U. S. Naval Research Laboratory, Washington, D. C.*—An experimental investigation of dependence of magnetization on magnetic field up to 67 000 gauss and on temperature down to 1.3°K has been made. At 295°K, the magnetization is linear in field where $(\partial M/\partial H)_T$ is 1×10^{-6} Bohr magnetons per gauss per atom of praseodymium. At 100°K, $(\partial M/\partial H)_T$ is 3×10^{-6} Bohr magnetons per gauss-atom, and remains linear up to 67 000 gauss. At 4.2°K, $(\partial M/\partial H)_T$ is 2×10^{-5} per gauss-atom up to 20 000 gauss, where the slope begins to decrease due to saturation effects. In 67 000 gauss, the magnetization is 1.04 Bohr magnetons per atom of praseodymium, and in the liquid helium range, $(\partial M/\partial T)_H$ is zero. This value of the magnetization, which from the appearance of the magnetization curve will not become much larger, is small compared with the value inferred from high temperature susceptibility data[1] (3.58 Bohr magnetons per atom) on the metal which value compares with the calculations (not including crystalline electric field effects) of Van Vleck and Frank (3.62 Bohr magnetons per ion, Pr^{+++}). The reluctance to saturate at 1.3°K and 67 000 gauss may indicate antiferromagnetism. There is a small remanence of 0.001 Bohr magneton per atom at 4.2°K and 0.002 at 1.3°K.

[1] Charlotte Henry la Blanchetais, J. recherches du centre natl. recherches sci. **6**, 103 (1954).

A4. Electron Mirror Microscopy of Magnetic Stray Fields on Grain Boundaries.* LUDWIG MAYER, *General Mills.*—Experimental evidence is presented that electron mirror microscopy is particularly well suited for direct visual observation of magnetic stray fields at grain boundaries in magnetic materials. Silicon-iron disks were used as specimens. By mounting these specimens on a special magnetic stage of axial symmetry, the appearance and the growth of magnetic stray fields with increasing external applied magnetic fields could be observed directly. Motion picture recordings taken from the viewing screen of the microscope demonstrate that grain boundaries behave quite differently stray fieldwise. The fact that magnetic stray fields on grain boundaries are now accessible to direct visual observation is considered valuable for many magnetic investigations. The still controversial subject of grain size effects on the magnetic properties of such important magnetic materials as silicon-iron is one subject which might profit from these potentialities inherent in electron mirror microscopy. This electronic observation method might also be helpful in grain boundary studies concerned with the basic physics of magnetics in such narrow regions of distorted order.

* This work was supported by the Aeronautical Research Laboratory of the Wright Air Development Center.

A5. Relation between Structure and Ferroelectricity in Lead Barium and Barium Strontium Niobates.* M. H. FRANCOMBE, *Philco Corporation* (introduced by J. F. Walsh).—X-ray crystallographic studies have been made of barium metaniobate, $BaNb_2O_6$, and of the ferroelectric solid solution series $(Pb,Ba)Nb_2O_6$ and $(Ba,Sr)Nb_2O_6$. $BaNb_2O_6$ possesses two polymorphic structures, a hexagonal form stable over a narrow temperature range below the melting point, 1450°C, and an orthorhombic form stable at lower temperatures. The single-phase $(Pb,Ba)Nb_2O_6$ and $(Ba,Sr)Nb_2O_6$ compositions are, like the room-temperature phase of $PbNb_2O_6$,[1] structurally related to the tetragonal tungsten bronzes, e.g., $K_{0.57}WO_3$. In the compounds $(Pb_{1-x}Ba_x)Nb_2O_6$ with $x<0.4$

the ferroelectric polar axis lies in the direction of one of the [110] axes of the related tetragonal structure, and this produces a slight orthorhombic distortion. High-temperature x-ray studies suggest that as x exceeds 0.5 the polar axis switches to the [001] axis. These ferroelectric strain effects have been attributed to the perovskite-like groups of atoms which form a part of the true repeat unit of the structure. The properties of the system $(Ba_{1-x}Sr_x)Nb_2O_6$ are broadly similar to those of the $(Pb,Ba)Nb_2O_6$ series, but, except at the Ba-rich end of the system, i.e., $x<0.2$, the Curie points are generally low, and the ferroelectric strain effects are small.

* This work was performed at the Research Laboratories of the General Electric Company, Ltd., Wembley, England.
[1] M. H. Francombe and B. Lewis, Acta Cryst. 11, 696–703 (1958).

Invited Paper

A6. Some Studies of Domain Dynamics in Barium Titanate (with moving pictures). R. C. MILLER, *Bell Telephone Laboratories.* (30 min.)

THURSDAY MORNING AT 10:30

Science Building 200

(J. R. WINCKLER presiding)

Electron Physics I, Including Phenomena in Gases

B1. Stroboscopic Electron Optical Schlieren Technique for Study of Molecular Beams. L. MARTON, S. R. MIELCZAREK, AND D. C. SCHUBERT, *National Bureau of Standards.**—We have previously reported[1] upon the development of electron optical schlieren photography for the study of gas density distributions at pressures below 10^{-4} mm Hg. A second instrument, designed to operate stroboscopically for study of reflected molecular beams,[2] has been constructed. Considerable manipulation of optical parameters was required to reduce background irregularities. These disturbances had caused difficulty in interpreting photodensitometer measurements of the schlieren photographs taken with the old instrument. In addition to cadmium beams, air and carbon-dioxide beams have been photographed. Stroboscopic operation involves synchronization of molecular beam pulses with electron beam pulses at a reproducibility rate of $\frac{1}{2}$ μsec. Spreading of the molecular beam bunch reduces the signal intensity, thus requiring a background vacuum better than 10^{-8} mm Hg. The stainless-steel system, which may be baked at 300°C, was operated below 10^{-7} mm Hg. The use of a liquid helium trap is expected to lower the pressure well below the design requirement. Means for varying the target incidence angle and temperature without breaking vacuum are provided.

* Work supported by the Office of Naval Research.
[1] Marton, Schubert, and Mielczarek, J. Appl. Phys. 27, 419 (1956).
[2] Natl. Bur. Standards (U. S.) Tech. News Bull. 41, 158 (1957).

B2. Range of Slow Electrons. CHARLES FELDMAN, *U. S. Naval Research Laboratory.*—The range of 1–10 kev electrons has been measured by a method involving the use of transparent luminescent films.[1,2] Twelve different materials, including both phosphors and metals have been studied. It has been found that the maximum practical range can be expressed to within 10% by $R=250A/\rho Z^{1/n}E^nAU$, where $n=1.2/(1-0.29\log Z)$; E=energy in kev; and ρ, A, Z, have their usual meaning. This expression differs from the usual range-energy relations in its dependency on Z. The greatest deviation occurs at high Z.

[1] L. R. Koller and E. D. Alden, Phys. Rev. 83, 684 (1951).
[2] C. Feldman, J. Opt. Soc. Am. 47, 790 (1957).

B3. Attachment of Near Thermal Energy Electrons in Oxygen.* L. M. CHANIN, A. V. PHELPS, AND M. A. BIONDI, *Westinghouse Research Laboratories.*—Studies of the attachment of low-energy electrons to oxygen previously reported[1] have been extended to near thermal energies (0.04 ev). Our previous measurements had shown that the attachment of electrons in oxygen consists of two separate processes. For $E/p>2$ attachment proceeds by a two-body process and for $E/p<2$, by a three-body process. For $E/p<2$ the three-body attachment coefficient was found to increase with decreasing electron energy to a value of 5×10^{-30} cm^6/sec for an average energy $\approx$0.09 ev. The present results show that as the average electron energy is reduced further the attachment coefficient decreases, reaching a value of 2.8×10^{-30} cm^6/sec at 0.04 ev. These results may be compared with the Bloch-Bradbury theory[2] of electron attachment in oxygen. Such a comparison reveals that the assumption of a delta-function attachment cross section is not valid. However, the energy of the observed maximum in the attachment coefficient is in agreement with the prediction of their theory.

* This work has been supported in part by the U. S. Air Force Special Weapons Center, Albuquerque, New Mexico.
[1] Chanin, Phelps, and Biondi, Bull. Am. Phys. Soc. Ser. II, 4, 2 (1959).
[2] F. Bloch and N. E. Bradbury, Phys. Rev. 48, 689 (1935).

B4. Drift Velocities of Slow Electrons in Nitrogen, Argon, and Neon.* J. L. PACK AND A. V. PHELPS, *Westinghouse Research Laboratories.*—The drift velocities of electrons have been measured at 77°K, 300°K, and 373°K in nitrogen for E/p values from 0.001 to 20 v/cm-mm Hg and at 77°K and 300°K in argon and neon for E/p values between 0.0004 and 0.1 v/cm-mm Hg. The data were obtained with the drift tube described previously.[1] The results agree with those of Nielsen[2] for E/p above 0.35 v/cm-mm Hg in nitrogen and above 0.05 v/cm-mm Hg in neon and argon. At the lower values of E/p in nitrogen and argon, the electron energy distribution is thermal and average values of elastic collision cross sections are easily obtained. The calculated cross sections for electrons in nitrogen agree in magnitude and energy dependence with those obtained by Phelps, Fundingsland, and Brown[3] and by Crompton and Sutton[3] but not with those of Anderson and Goldstein.[4] The average elastic scattering cross section in argon decreases by about a factor of five as the electron temperature increases from 77°K to 300°K.

* This work was supported in part by Contract NONR-2584(00), Advanced Research Projects Agency 5-58 Task 1 and the Office of Naval Research.
[1] J. L. Pack and A. V. Phelps, Phys. Rev. 100, 1229A (1955).
[2] R. A. Nielsen, Phys. Rev. 50, 950 (1936).
[3] Phelps, Fundingsland, and Brown, Phys. Rev. 84, 559 (1951); R. W. Crompton and D. J. Sutton, Proc. Roy. Soc. (London) A215, 467 (1952).
[4] J. M. Anderson and L. Goldstein, Phys. Rev. 102, 388 (1956).

B5. Negative Ion Formation in NO_2 by Electron Attachment. R. E. Fox, *Westinghouse Research Laboratories.*—Negative ion formation in NO_2 by electron attachment is studied at low pressures as a function of electron energy. The instrument used is a mass spectrometer employing the retarding potential difference (RPD)[1] method of studying ionization produced by essentially monoenergetic electrons. The principal ion formed is found to be O^-. The onset as determined from a retardation of the electron beam occurs at 1.35 ± 0.05 ev. The apparent peak maximum is at 1.90 ev. However, from a comparison of the peak shape with the shape of the electron energy distribution the maximum cross section for attachment occurs within 0.1 ev of the threshold. The half-width of the O^- peak is 0.45 ev compared to the electron energy distribution with a half-width of 0.2 ev. The O^- cross section becomes negligible at about 1.4 ev above threshold. A small peak attributed to NO_2^- is found to have approximately the same energy dependence as the O^- peak. Crude estimates of the cross section for attachment yield order of magnitude values of 10^{-18} cm² for O^- and 10^{-20} cm² for NO_2^-.

[1] Fox, Hickam, Grove, and Kjeldaas, Rev. Sci. Instr. **26**, 1101 (1955).

B6. General Theory of the Microwave Conductivity of a Plasma in a Magnetic Field.* Don C. Kelly, *Yale University.*—Time-independent perturbation theory is employed to solve the Boltzmann equation for the distribution function of electrons in a plasma subjected to crossed fields (rf electric, constant magnetic). Expressing the distribution function as a series of orthogonal functions leads to a set of first-order differential equations for the expansion coefficients. The real and imaginary parts of the conductivity tensor are expressed as the ratio of finite determinants—the order of which increases with the number of terms used in the expansion of the distribution function. The effect of electron-electron encounters is shown to be greatest near the cyclotron resonance frequency. Convergence of the series is rapid over most of the range of electric field strengths and pressures employed in microwave discharges. The theory is valid for weakly as well as highly ionized plasmas.

* Supported by the Office of Naval Research.

B7. Cluster Approach to the Statistical Theory of Line Broadening by Ions.* H. K. Wimmel and M. B. Lewis, *Yale University.*—A general expression in terms of cluster integrals is derived for the field distribution function in a dilute gas, arbitrary particle fields and short-range interactions between these particles being assumed. The formula obtained reduces to Holtsmark's function for an idealized plasma containing ions whose interaction is neglected. By introducing a hard-sphere repulsion in this model and taking into account one- and two-particle cluster integrals only, the peak of the field distribution shifts towards a field strength that is smaller by a factor $\lambda = [1 - \{4\pi(\sqrt{2}-1)D^3 n/3\}]^{\frac{1}{2}}$, where D = radius of the hard-sphere potential, and n = particle density. For a certain range of variables (small fields, low ion densities) the new function is approximately a shifted Holtsmark distribution.

* Work supported by the U. S. Air Force.

B8. Dispersion Energies between Alkalis and Noble Gas Atoms.* Peter Fontana, *Yale University.*—The use of an irreducible tensor formalism and the theory of angular momentum permits the evaluation of the dispersion energy between two atoms or molecules in more convenient form. Such calculations have usually been carried out by writing the interaction potential in Cartesian coordinates; this becomes very complicated for higher multipoles and makes the evaluation of contributions of higher-order multipoles difficult. We treat here the interaction between two noble gas atoms assuming that each electron oscillates with simple harmonic motion, and the interaction between alkali atoms by considering the electrons to be moving in a Coulomb field. The dipole-octupole contributions, hitherto neglected are computed; they are larger than the quadrupole-quadrupole terms listed by Margenau.[1] Hydrogenic wave functions can also be used with success in treating the interaction between noble gas atoms. The relative contributions of the multipole interactions of He-He are within 2% of the results obtained by Page[2] in a variational calculation.

* Work supported by the Office of Naval Research.
[1] H. Margenau, J. Chem. Phys. **6**, 896 (1938); Phys. Rev. **38**, 747 (1931).
[2] C. H. Page, Phys. Rev. **53**, 426 (1938).

Thursday Morning at 10:30

Science Building 300

(H. W. Lewis presiding)

Nuclear Theory

C1. Electromagnetic Structure of the Nucleons. J. M. Barnothy, *Evanston.*—High-energy electron scattering experiments have been interpreted as evidence for the finite size of nucleons. The presented model of elementary particles was conceived in the course of an attempt to eliminate metaphysical creation acts, inherent in all present day cosmologies. The proposed cosmological solution is identical with the static solution of the general relativity theory. In this universe, however, redshift, Stebbins-Whitford effect, cosmic radiation, and cosmological constant are different manifestations of the same phenomenon: a change in the metric of the signal carriers relative to the metric of the elementary particles. The model of the elementary particles sets out from the assumption that elementary particles are static universes like our own, with smaller length and mass units, owing to the curvature of their space, the intersection of these "smaller universes" with our space will be a finite surface of constant Gaussian curvature. The known elementary particles are derived from the different admissible static cosmological solutions. The model provides for the electromagnetic structure of the proton a form factor of $F_e = F_m = (1+4q^2\lambda^2)^{-1}$; for that of the neutron $F_e = 6\times10^{-4}q^2$ and $F_m = (1+4q^2\lambda^2)^{-1} - 1.5\times10^{-2}q^2$; for that of the alpha particle $F_e = (1-4q^2\lambda^2) \times(1+4q^2\lambda^2)^{-1} + 0.013q^2$, where λ is the Compton wavelength of the proton and q the energy momentum transfer.

C2. Elastic Scattering and Polarization of High-Energy Nucleons by Nuclei.* Alvin M. Saperstein and David Feldman, *Brown University.*—The cross section and polarization for the elastic scattering of protons by carbon and lead at 135 Mev and by carbon at 300 Mev have been evaluated in the impulse approximation, using the nucleon-nucleon phase-shift sets of Signell-Marshak, Gammel-Thaler, Ohnuma-Feldman, and Stapp. The detailed calculations have been

carried out both in ordinary Born approximation and also in terms of a modified Born approximation in which account is taken of the absorption of the elastically scattered nucleon wave within the nucleus. Relativistic effects have been estimated and have been found to be small. With particular reference to the carbon data at 135 Mev it is found that the Signell-Marshak phase shifts provide a better fit of the polarization data than do the remaining phase-shift sets; so far as the cross sections are concerned the situation is not quite so clear. The possibility of distinguishing in this way among the various sets of nucleon-nucleon phase shifts will be discussed.

* Supported in part by the National Science Foundation.

C3. α-Transition Probabilities on the basis of the Nuclear Shell Model.* H. J. MANG, *University of California, Berkeley.*—A previously developed theory of α decay is used to calculate the reduced α widths for about 30 α emitters of the even-even and the even-odd type in the region around the double closed shell nucleus Pb^{208}. The nuclear wave functions, which enter into the expression for the reduced width are approximated by simple shell-model wave functions. Even numbers of protons or neutrons are coupled in pairs to give a total angular momentum zero. A comparison with experimental results shows good agreement. Especially the behavior of the reduced widths when crossing the closed neutron shell ($N=126$) is well reproduced.

* This work was done partly under the auspices of the U. S. Atomic Energy Commission.

C4. Statistical Properties of Shell-Model Matrices.* C. E. PORTER AND N. ROSENZWEIG, *University of Minnesota and Argonne National Laboratory.*—Arguments based on the central limit theorem and agreement between Monte-Carlo machine calculations and data on the widths and spacings of nuclear fine structure levels lead to the hypothesis that the matrix elements of the nuclear Hamiltonian are normally distributed.[1,2] In order to shed further light on this hypothesis, we have examined the statistical properties of shell-model matrix elements arising in studies of relatively low-lying states.[3] We and that the matrix elements constructed in *j-j* coupling in the *l-p* shell (Kurath[3]) follow a normal distribution. The distribution of the matrix elements arising from calculations using a combined version of the collective and shell model in the $f_{7/2}$ shell (Raz[3]), while not normal, is symmetric about the most probable value of zero.

* Work performed under the auspices of the U. S. Atomic Energy Commission.
[1] S. Blumberg and C. E. Porter, Phys. Rev. **110**, 786 (1958).
[2] N. Rosenzweig, Phys. Rev. Letters **1**, 101 (1958).
[3] D. Kurath, Phys. Rev. **101**, 216 (1956); J. B. Raz (private communication). We wish to thank Dr. Kurath and Dr. Raz for making their matrices available.

C5. On the Statistics of Nuclear Level Spacings.* P. A. MOLDAUER, *Argonne National Laboratory.*—It is proved that for any smooth distribution of nuclear level spacings the probability of finding a level between distances S and $S+dS$ from another level approaches $D^{-1}\,dS$ for large S where D is the mean spacing. This probability function is obtained for several different distributions and is applied to the problem of correcting experimental distributions for missed levels. Analysis of recently reported level data[1,2] obtained by slow neutron bombardment of U^{234}, U^{236}, U^{238} shows the distribution of spacings to agree well with the Wigner distribution[3] and not so well with other distributions that have been considered, and that the distinction is statistically significant.

* Work performed under the auspices of the U. S. Atomic Energy Commission.
[1] Rosen, Havens, Rainwater, and Dejardins, Bull. Am. Phys. Soc. Ser. II, **4**, 33 (1959).
[2] John A. Harvey and D. J. Hughes, Phys. Rev. **109**, 471 (1958).
[3] E. P. Wigner, Conference on Neutron Physics by Time of Flight, Oak Ridge National Laboratory Report ORNL-2309 (1956), p. 59.

C6. Cranking Model Calculation of Nuclear Moments of Inertia. EUGENE D. HAUG AND MURRAY PESHKIN, *Northwestern University.*—Inglis' cranking model, wherein nucleons move independently in an anisotropic oscillator potential, gives the rigid-body moment of inertia I_r for nonspherical nuclei. The experimental values are about half I_r. It has often been speculated that $I=I_r$ independently of the assumed collective potential shape, at least in the limit of large particle number, A. We consider a rotated quantum mechanical gas in a rectangular box. Our model differs from Inglis' mainly in the hard walls. The corners give recognizable spurious effects. Only three examples have thus far been calculated, near $A=70$. Two cases give I near I_r, but in one case $I=0.3I_r$. A general survey will be presented. It is interesting to note that the large A limit is probably irrelevent to nuclei because even for $A=250$, the Fermi level is comparable to the energy spacing. Furthermore, wall effects are never negligible even for infinite A.

C7. Significance of the Rules of 4 and 6 in Relation to the Atomic Weights of Isotopes. N. EFREMOV, *1061 Intervale Avenue, New York.*—The sums of two mass differences between the chief isotopes of triads of elements, e.g.,

Elements:	Na	Mg	Al	
Atomic weights:	23	24	27	
Mass differences:	1	3	=	4,

in the successive series of chemical elements: H, He, Li, ...U...Pu...Bk, cf, theoretically can equal any simple small number as 1,2,3,4,5,6,7, etc. But the analysis of the previously stated regularities let us conclude that the prevailing role among these numbers of sums of mass differences belongs to the first composite small numbers: $4(2\times2)$ and $6(2\times3)$. This conception is supported by empirical data. Deviations from these rules are of special interest, e.g., the sums of mass differences in the triad: $Bi_{209}-Po_{210}-At_{210}$ (with an artificial element, Astatine) equals 1. Note also the significance of rules of 4 and 6 in cosmic abundance of chemical elements.

THURSDAY AFTERNOON AT 2:00

Science Building 100

(V. W. HICKS presiding)

Invited Papers

E1. Oscillatory Dependence of Temperature on Magnetic Field. J. E. KUNZLER, *Bell Telephone Laboratories.* (30 min.)

E2. Excitons in Zinc Oxide and Cadmium Sulfide. D. G. THOMAS, *Bell Telephone Laboratories.* (30 min.)

Semiconductors

E3. Diffusion Rate of Li in Si between 25°C and 125°C.* E. M. PELL, *General Electric Research Laboratory.*—The diffusion rate of Li in Si has been measured previously.[1,2] We wish to report some recent measurements by a new technique which yields high accuracy at lower temperatures. In this technique, the electric field in a reverse-biased Si np junction in which Li is the donor is used to drift the Li ions to produce an intrinsic region. The rate of growth of the intrinsic region and hence the drift rate of the Li^+ is measured by monitoring the junction capacitance. In floating-zone Si of low oxygen content and low acceptor concentration such measurements yield the diffusion constant of Li in Si. A series of experiments in such material in the temperature range 25°C–125°C, gives $D=2.6\times10^{-14}$ cm²/sec at 25°C, with an activation energy of 0.61 ev.

* Supported in part by the U. S. Air Force Cambridge Research Center.
[1] C. S. Fuller and J. C. Severiens, Phys. Rev. **96**, 21 (1954).
[2] J. P. Maita, J. Phys. Chem. Solids **4**, 68 (1958).

E4. Zener Tunneling in Semiconductors. EVAN O. KANE, *General Electric Research Laboratory.*—The Zener current in a constant field is calculated both with and without the Wannier-Adams[1] reduction of the interband coupling terms. The Zener current is only slightly different in the two cases, a fact which has already been noted by Wannier. The apparent reduction of interband coupling is interpreted as a polarization correction. A detailed calculation of the Zener current is made for a simple two-band model which is roughly applicable to InSb. The method used follows closely a calculation due to Keldysh.[2] The barrier transmission coefficient Z^2 is calculated to be $Z^2=(\pi^2 m_r E_G/36\hbar^2 q^2)\exp\{-\pi\hbar q^2 E_G^{\frac{1}{2}}/2eFm_r^{\frac{1}{2}}\}$ where E_G is the band gap, F the electric field, m_r is the reduced mass of the electron, and hole $m_r^{-1}=m_e^{-1}+m_h^{-1}$, and q^2 is given by $q^2=(m_r E_G/\hbar^2)+k_\perp^2$. The vector perpendicular to the field, $k_\perp$, is a constant of the motion. The number of electrons per sec per cc, n, which leak from the filled valence band to the conduction band is found to be

$$n=(F^2 m_r^{\frac{1}{2}}/18\pi\hbar^3 E_G^{\frac{1}{2}})\exp\{-\pi m_r^{\frac{1}{2}} E_G^{\frac{3}{2}}/2\hbar eF\}.$$

[1] E. N. Adams, Phys. Rev. **107**, 698 (1957).
[2] L. V. Keldysh, Soviet Phys. JETP **6(33)**, 763 (1958).

E5. Source of the Additional Pulse in Semiconductor under High Microwave Field. A. AHARONI* AND K. ROSE, *University of Illinois.*—When a semiconductor crystal is placed in a high microwave field, a dc voltage appears across it in a direction parallel to the microwave electric field and introduces an error in the measurements of its properties. This "additional pulse" is proportional to the microwave power and changes both amplitude and polarity when a short terminating the system is moved. The measured characteristics of the additional pulse were roughly in agreement with a first-order calculation of the dc current produced by the second harmonic present in the magnetron signal, in the third harmonic produced by the nonlinearity of the semiconductor due to electron heating. A microwave filter which passed unattenuated power at the fundamental frequency, attenuated the second harmonic amplitude by a factor of 6 and reduced the additional pulse by a factor of 4. Since the distribution of power among the modes which the second harmonic can support in the wave guide is not known, only a rough estimation can be made and this gives satisfactory agreement.

* On leave from the Weizmann Institute of Science, Rehovoth, Israel.

E6. Magnetoresistance of n-InSb in the Quantum Limit. R. J. SLADEK, *Westinghouse Research Laboratories.*—Resistivity measurements on high mobility (500 000 $cm^2V^{-1}S^{-1}$ at 77°K) n-type InSb have been made in longitudinal and transverse magnetic fields up to 28 kilogauss between 50°K and 90°K. It was found that above 15 kilogauss the transverse resistivity, $\rho_T\sim H^{0.9}T^{-0.4}$, where H is the magnetic field and T the temperature, while the longitudinal resistivity ρ_L was independent of H but increased slowly with increasing temperature. At 28 kilogauss ρ_T was about 10 times ρ_L, the actual factor being temperature dependent. These results are in qualitative accord with predictions of recent theory[1] for piezoelectric or polar optical scattering in the quantum limit ($\hbar\omega\gg kT$). Quantitative discrepancies may be due to our not having attained the quantum limit experimentally, and the presence of some ionized impurity scattering. The latter seems to be most evident in the longitudinal field case at lowest temperatures as would be expected.

[1] Adams and Holstein, Westinghouse Research Laboratories Scientific Paper 6-94760-2-P18 [Phys. Rev. (to be published)].

E7. Weak-Field Magnetoresistance in Nearly Pure n-Type Silicon. JOHN MYERS AND DONALD LONG, *Honeywell Research Center.*—Measurements of the weak-field magnetoresistance coefficients b, c, and d, and the Hall mobility were made at 300° and 77°K on several samples of relatively pure n-type silicon in which impurity scattering was insignificant. The symmetry condition, $b+c+d=0$, for the known 6-spheroid conduction band structure,[1] was approximately (but generally not exactly) satisfied at both temperatures, the quantitative discrepancy being less than 15% of b in each case. The ratio $K=(m_{t\tau_t}/m_{l\tau_l})$, which characterizes the combined effective-mass and relaxation-time anisotropy in an energy spheroid, was found from our data to lie within 10% of $K=5.2$ at 300°K and within 15% of $K=5.7$ at 77°K. Since $m_l/m_t\sim5.2$, and should be nearly temperature independent, these results indicate that the lattice scattering is isotropic at room temperature (as expected theoretically for dominant intervalley or optical-mode scattering[1]), and is nearly so at 77°K. More precise measurements are needed to reduce the foregoing uncertainties in the symmetry condition and K, which are probably caused mostly by marked sensitivity to experimental errors.

[1] C. Herring, Bell System Tech. J. **34**, 237 (1955); C. Herring and E. Vogt, Phys. Rev. **101**, 944 (1956).

THURSDAY AFTERNOON AT 2:00

Science Building 200

(P. L. HARTMAN presiding)

Invited Papers of the Division of Electron Physics

F1. Hydrogen Radiation in the Night Sky. J. W. CHAMBERLAIN, *Yerkes Observatory.* (30 min.)

F2. Origin and Atmospheric Effects of Auroral X-Rays. J. R. WINCKLER, *The University of Minnesota.* (30 min.)

F3. Properties of the Plasma Diode. H. W. LEWIS, *University of Wisconsin.* (30 min.)

THURSDAY AFTERNOON AT 2:00

Science Building 300

(G. E. UHLENBECK presiding)

Invited Papers

G1. Fast-Neutron Capture Cross Sections. H. H. BARSCHALL, *University of Wisconsin.* (30 min.)

G2. Elastic Scattering of Nitrogen Ions from Light Nuclei. M. L. HALBERT, *Oak Ridge National Laboratory.* (30 min.)

Nuclear Physics I (Nuclear Reactions)

G3. Cross Sections for the $B^{11}(\gamma,\pi^-)C^{11}$ and $B^{11}(\gamma,\pi^+)Be^{11}$ Reactions.* JOHN P. HUMMEL AND PALMER DYAL, *University of Illinois.*—Yields for the foregoing reactions have been measured from their thresholds to 300 Mev. Samples of $B_{10}H_{14}$ were irradiated with bremsstrahlung from the Illinois 300 Mev betatron and the C^{11} and Be^{11} activities were measured with scintillation detectors. Preliminary values for the cross sections obtained from the yield curves in units of 10^{-30} cm² are given in Table I. The cross sections for $B^{11}(\gamma,\pi^-)C^{11}$

TABLE I.

E_γ(Mev)	150	170	190	210	220	250	280
$\sigma B^{11}(\gamma,\pi^-)C^{11}$	19.0	39.0	41.6	37.5	34.0	23.0	13.0
$\sigma B^{11}(\gamma,\pi^+)Be^{11}$	...	4.25	5.25	5.50	5.30	4.50	3.50

agree with the previous measurements of Hughes and March[1] and the theoretical predictions of Laing and Moorhouse.[2] Results of cross-section calculations for $B^{11}(\gamma,\pi^+)Be^{11}$ using the model proposed by Laing and Moorhouse[2] will be presented.

* Work supported by the Office of Naval Research.

[1] Hughes and March, Proc. Phys. Soc. (London) **72**, 259 (1958).

[2] Laing and Moorhouse, Proc. Phys. Soc. (London) **70**, 629 (1957).

G4. Angular Distributions for the (p,n) Reaction in Mirror-Nucleus Targets: C^{13} and B^{11}.* S. D. BLOOM AND R. D. ALBERT. *University of California, Livermore.*—Pursuant to the suggestion[1] recently made with regard to the (p,n) reaction connecting ground states in mirror nuclei, angular distribution measurements have been made on the neutrons using a long counter as a detector. The targets for these runs were enriched C^{13} sputtered on a Ta backing and enriched B^{11} similarly mounted. The likelihood of direct interaction being the predominant mechanism for this reaction[1] is supported here at all energies from threshold to the top measurable energy (~5.5 Mev for C^{13}, and ~5.1 Mev for B^{11}), which is determined by the excitation of the first excited states in the residual nuclei, N^{13} and C^{11}, or the beginning of the $(p;p,n)$ breakup process, whichever occurs first. Strong forward peaking at threshold characterizes both reactions, and the onset of more complicated angular distributions at higher energies occurs qualitatively in the same way for both. Theoretical fits have been attempted using distorted waves[2] and a simplified direct interaction model ignoring spin-flip and inner volume processes. These fits and other implications of the experiment will be discussed.

* Work performed under auspices of the U. S. Atomic Energy Commission.

[1] Bloom, Lemmon, and Moszkowski, Bull. Am. Phys. Soc. Ser. II, **3**, 418 (1958).

[2] Norman K. Glendenning (to be published).

G5. $C^{12}(t,p)C^{14}$ and $C^{12}(t,\alpha)B^{11}$ Angular Distributions at 1.5 Mev. G. D. GUTSCHE,* *The Catholic University of America,* AND H. D. HOLMGREN AND R. L. JOHNSTON, *U. S. Naval Research Laboratory.*—The angular distributions of the ground-state proton group from the $C^{12}(t,p)C^{14}$ reaction and the ground-state alpha group from the $C^{12}(t,\alpha)B^{11}$ reaction have been measured at a bombarding energy of 1.5 Mev at 17 angles from 0° to 130°. The proton distribution is strongly peaked in the forward direction and has a minimum at 75°. The peak-to-valley ratio is about 10. Over the range of observation the proton distribution is rising in the backward direction. The alpha particle distribution shows a broad maximum at about 70°.

* National Science Foundation Science Faculty Fellow, 1958–1959; on leave from U. S. Naval Academy.

G6. (n,d) Reactions on P^{31} and S^{32}. F. L. HASSLER, M. R. ZATZICK, AND H. P. EUBANK, *Brown University.*—In the course of (n,p) cross-section measurements, strong (n,d) ground-state transitions were observed in N^{14}, P^{31}, and S^{32}. The latter two nuclei, involving 3 and 4 nucleons in the $2s$ subshell, and $l_{min}=0$ allowed transitions, give rise to strong forward peaks similar to that of $F^{19}(n,d)$.[1] The angular distributions are well fitted to the direct interaction form[2] with the Wronskian instead of jl^2 and radii approximately 10% larger than the stripping radii.

[1] F. L. Ribe, Phys. Rev. **106**, 767 (1957).

[2] S. T. Butler, Phys. Rev. **106**, 272 (1957).

G7. Neutron-Induced Fission Cross Section of Neptunium-237 as a Function of Energy. H. W. SCHMITT AND R. B. MURRAY, *Oak Ridge National Laboratory.*—The fission cross section of Np^{237} has been measured as a function of neutron energy in the range 0.9 to 8.0 Mev. Measurements above 1.7 Mev were made relative to the known U^{238} fission cross section. Thin deposits of Np^{237} and U^{238} on platinum backings were placed back to back in an ionization chamber; fission fragments from each deposit were counted in 2π geometry. Monoenergetic neutrons from the $T(p,n)He^3$ and $D(d,n)He^3$ reactions were incident on the deposits. Masses of the various Np and U deposits were determined in separate experiments by alpha counting. In the range 0.9 to 2.9 Mev a secondary neutron monitor was used and the results were normalized to those of the comparison counting experiment in the overlapping energy range. Results indicate that the cross section increases above threshold to a maximum value of 1.7 barns at ~2 Mev, decreases to 1.36 barns at ~5 Mev, and increases again to 2.08 barns at 8 Mev. Estimated uncertainty in the absolute magnitude of $\sigma_{fiss}(Np)$ is ±8%. These results differ somewhat both in magnitude and shape from those in BNL-325, second edition.

FRIDAY MORNING AT 10:00

Science Building 100

(R. E. FOX presiding)

Electron Physics II: Electron Emission from Solids

L1. Thermionic Emission from Thin Films of Barium Oxide on Platinum Single Crystal. H. F. WEBSTER, *General Electric Research Laboratory.*—An emission microscope has been used to observe the pattern of thermionic electron emission from single-crystal platinum hemispheres which have been coated with thin films of barium oxide. The microscope yields magnification of the order to 200 diam. The results obtained show that the emission current depends strongly on the crystallographic face of the underlying platinum base metal. In the case of polycrystalline platinum hemispheres, the emission patterns are complex but appear the same when the barium oxide film is evaporated off and a new film added.

L2. Thermionic Emission Characteristics of a Thorium Carbide Heat Converter.* RAYMOND FOX AND WILLIAM GUST, *University of California, Livermore.*—The thermionic emission characteristics of thorium carbide in a cesium space charge neutralized diode geometry has been measured. A guard ring cylindrical diode was built using thorium carbide as the cathode and nickel as the anode. The cesium pressure was adjusted so that space charge neutralization occurred. The anode temperature was adjusted so that a monolayer of cesium formed on the anode. The power input of the diode heat converter was measured from the total power used in heating the cathode. This was checked with the power expended in heating the anode plus the power output of the tube. The two measurements were in agreement. The effective emissivity and the work function of thorium carbide was also measured. A converter efficiency greater than 15% and an electrical power output greater than 15 w/cm² has been obtained. Results and characteristics of the diode will be presented.

* This work was done under the auspices of the U. S. Atomic Energy Commission.

L3. Retarding Field Studies on Oxide Cathodes. J. E. DAVEY, *Naval Research Laboratory.*—Retarding field behavior has been studied in the temperature range from 450 to 900°K and from saturation to a lower current range of 10^{-15} amp. Measurements were made in both close-spaced planar and cylindrical geometry, in such a manner as to allow elimination of errors due to temperature variations, resistive effects in the cathode and anode, and photoemission effects. Electron temperatures as computed from retarding characteristics are always higher than lattice temperature by at least 30°, for measurements in both geometries. However, in general, the measurements do not show the increase in temperature difference with increasing temperature as reported by Bulyginsky and Dobretsov.[1] The temperature dependence of the work function, as measured from CPD shift with temperature, ranges from 3.1 to 6.8×10^{-4} ev/°K. Donor densities estimated from CPD shift data and from extrapolated Richardson lines obtained by both dc-zero field and strong-field pulsed data give order-of-magnitude agreement. The lack of agreement between electron temperature and lattice temperature is described in terms of patch effects at the collector.

[1] D. G. Bulyginsky and L. N. Dobretsov, J. Tech. Phys. U. S. S. R. **26**, 1141 (1956).

L4. Photoelectric Schottky Deviation in Tungsten Single Crystals.* D. F. STAFFORD, A. H. WEBER, AND T. H. ZEPF, *Saint Louis University.*—Photoelectric Schottky deviations have been obtained experimentally for emission from the (111) crystallographic planes of a tungsten single crystal grown in a filamentary cathode (cylindrical geometry) of 0.004-in. diameter wire. Vacuum conditions, circuit sensitivity, and stability, together with the control or elimination of anomalous currents in the phototube, have resulted in reproducibility of data sufficient to exhibit the expected deviations. Although the deviations obtained are in general agreement with the various theories, the experimental period is larger and the amplitude shows a rough constancy rather than increasing with increasing electric field strength. Photoelectric deviations will be compared with thermionic deviations obtained with the same tungsten specimen under the same experimental conditions.

* Research supported by Office of Ordnance Research.

L5. Photoelectric Emission from Nickel. IRVING AMES AND R. L. CHRISTENSEN, *IBM Research Laboratory.*—Because of the significance[1] of the anomalous temperature variation of the photoelectric yield from nickel,[2] a re-examination of this phenomenon has been made. The nickel was a high-purity vacuum melted polycrystalline ribbon mounted in a clean vacuum.[3] The pressure was about 10^{-10} mm Hg, except during initial periods of sample outgassing. Attainment of surface stability (reproducibility of photoelectric characteristics) required vigorous heat treatment of the sample, including evaporation of about 10 000 A of surface material. Measurements were made at wavelengths from 2150 to 2650 A and over temperatures from 27 to 700°C. In contrast with previous results,[2] the temperature variation of yield for various wavelengths continues to rise above the Curie point, although it exhibits an upward bulge in that vicinity. These and spectral distribution data, at fixed temperatures within the indicated range, follow Fowler theory with a work function of 4.92 ± 0.03 ev, except in the vicinity of the Curie point where there is a minimum of 4.85 ± 0.03 ev.

[1] A. Z. Veksler, J. Exptl. Theoret. Phys. U. S. S. R. **29**, 201 (1955). [English translation: Soviet Phys. JETP **2**, 266 (1956)].
[2] Alvin B. Cardwell, Phys. Rev. **76**, 125 (1949).
[3] R. L. Christensen and I. Ames, Bull. Am. Phys. Soc. Ser. II, **4**, 139 (1959).

L6. Evaporated Ag-Mg Thin Film Secondary Emitters.* M. J. NEUMANN, G. FRANCIS, AND J. BURNS, *Chicago Midway Laboratories.*—Secondary emission surfaces having moderately high, stable yields at low primary energies have been prepared by evaporating Ag-Mg alloy containing 4% Mg.[1] The evaporation was performed by evaporating completely a large number of small pellets of the alloy, one at a time. The resulting film 1000–10 000 A thick was oxidized at 500°C in pure O_2 at 100–300-μ pressure. Secondary emission ratios approximately 5 at primary energies of 200 ev were obtained. The yields appear fairly stable to exposure to the atmosphere and to gases evolved in glass-sealing operations.

* Research supported by the U. S. Atomic Energy Commission.
[1] Z. Bay, Rev. Sci. Instr. **12**, 127 (1941).

L7. Perfection of Metal Crystal Surfaces by Field Evaporation.* ERWIN W. MÜLLER, *Pennsylvania State University.*—The habit of a field evaporated metal crystal is a result of the condition that the field, determined by applied voltage and surface geometry, removes ions from all surface elements at

the same rate. For a high-purity crystal a rounded off shape is expected with the local radius of curvature varying in the same sense as the work function of the considered region.[1] A perfect surface with high index net planes can only be developed with high purity materials. If in a cubic lattice the highest Miller index of an appearing plane is h, the concentration of impurities must be less than $1/h^3$, and the minimum tip radius which will allow the development of such a plane is approximately h^3 times the half lattice constant. Experimental examples are shown of pure crystals of the platinum metals exhibiting more than 1000 facet-like net planes with Miller indices up to 11, and of similar tungsten crystals and iron whiskers. Impure crystals and alloys assume an irregular surface because of local randomness of work function and work to field evaporate an ion.

* Supported in part by the Air Force Office of Scientific Research.
[1] E. W. Müller and J. F. Mulson, Bull. Am. Phys. Soc. Ser. II, 3, 69 (1958).

L8. Polarization of the Edge Emission in CdS.* R. J. COLLINS AND J. J. HOPFIELD, *Bell Telephone Laboratories.*—The intensity of the edge emission in hexagonal CdS has been observed[1] to be preferentially polarized perpendicular to the c axis. Measurements have been made of the ratio of the green emission on $(11\bar{2}0)$ cleavage surfaces polarized parallel and perpendicular to the c axis from 68°K to 150°K. Over this interval the ratio can be represented by $I_{\perp}/I_{\parallel} \sim \exp(+\Delta E/kT)$. This result is interpreted in terms of a Boltzmann distribution of holes trapped in a localized energy level with a split ground state. The splitting of the level is a consequence of the crystal field splitting of the valence band. A value for ΔE of 0.014 ev is observed. Similar measurements for the exciton decay at ~4870 A give a larger ratio at 78°K and can be interpreted in terms of the valence band structure. From the wavelengths of the exciton decay and the green emission the hole trap responsible for green edge emission is found to be 0.15 ev above the valence band. Evidence will be presented for the assignment of the level as a hole trap. Crystals for this work were supplied by D. C. Reynolds of the Wright Air Development Center.

* This work was supported in part by the Wright Air Development Center of the U. S. Air Force.
[1] D. Dutton, J. Phys. Chem. Solids 6, 101 (1958).

L9. Electron Irradiation Effects in CdS. B. A. KULP AND R. H. KELLEY, *Aeronautical Research Laboratory.*—Reynolds and Greene[1] have previously reported the production of edge emission centers in whiskers of CdS by electron bombardment at energies of 400 and 700 kev. Further experiments have shown that the threshold for the production of edge emission in crystals, which initially do not show this phenomenon, is about 130 kev. Resistance measurements confirm the threshold energy. Bombardment of unannealed crystals by electrons results in an effect which is much like thermal annealing. That is, in crystals which show edge emission, the edge emission may be removed either by electron bombardment or by thermal annealing at 450°C for a few hours. In more nearly perfect platelet crystals the thermal annealing is appreciable even at 175°C. In fact, edge emission is removed by long bombardment with electrons of energies as high as 200 kev, even though this is above the threshold for the production of edge emission in crystals which initially do not show it.

[1] D. C. Reynolds and L. C. Greene, Bull. Am. Phys. Soc. Ser. II, 3, 108 (1958).

FRIDAY MORNING AT 9:45

Medical School Auditorium

(L. W. FRIEDRICH presiding)

Symposium on the Nature of Physical "Knowledge"

M1. Can Physical "Knowledge" Be Expected to Lead to a Full Understanding of Reality? P. W. BRIDGMAN, *Harvard University.* (30 min.)

M2. Is Physical "Knowledge" Defined or Limited by Its Method of Inquiry? PHILIPP FRANK, *Harvard University.* (30 min.)

M3. Does Physical "Knowledge" Require *a priori* or Undemonstrable Presuppositions? HENRY MARGENAU, *Yale University.* (30 min.)

M4. Does "Knowledge" of Physical Laws and Facts Have Relevance in the Moral and Social Realm? GEORGE KLUBERTANZ, *St. Louis University.* (30 min.)

FRIDAY AFTERNOON AT 2:00

Medical School Auditorium

(HENRY MARGENAU presiding)

Symposium on the Nature of Physical "Knowledge," continued

N1. Can Physical "Knowledge" be satisfied with a Dualistic Picture rather than a Unitary Reality? A. LANDE, *Ohio State University.* (30 min.)

N2. Discussion. FRANK COLLINGWOOD, ADOLF GRUNBAUM, AND R. L. SEEGER.

FRIDAY AFTERNOON AT 2:45

Science Building 200

(H. H. BARSCHALL presiding)

Invited Paper

P1. Studies of Neutral *K* Mesons with Emulsion Techniques. UGO CAMERINI, *University of Wisconsin.* (30 min.)

Nuclear Physics II

P2. The Radiative Decay of the μ Meson. R. R. CRITTENDEN AND W. D. WALKER,* *The University of Wisconsin*, AND J. BALLAM,† *Michigan State University.*—We are studying the process $\mu^+ \rightarrow e^+ + \nu + \bar{\nu} + \gamma$ by looking at stopping μ mesons from the Carnegie Tech synchrocyclotron. The π's and μ's are observed to stop in a small (5-in. diam) Freon bubble chamber. The radiation length in the Freon is about 15 cm so that there is a sizable chance of conversion. We see about 1 pair per one thousand stopping μ's. In the process of looking at 120 000 stopping μ's so far we have found no examples of $\mu \rightarrow 3e$ or $\mu^+ \rightarrow e^+ + \gamma$.

* Supported in part by the Wisconsin Alumni Research Foundation and U. S. Atomic Energy Commission.
† Supported in part by a grant from the National Science Foundation.

P3. Heavy Nuclei in the Primary Cosmic Rays over Minnesota. EIJI TAMAI, *University of Minnesota.*—The analysis of the heavy primary cosmic rays ($Z \leq 2$) has been made, by using the *G*-stack emulsion which was exposed for about 6.5 hours at an altitude of 35 km (6.7 g/cm²) on September 18, 1956, over Minnesota. In order to examine the low rigidity portion of the heavy primary cosmic rays, we have recorded only the stopped particles in this stack. In this work, we have employed the two methods to identify the charges of various particles: (1) track width measurement and (2) δ-ray density *vs* residual range. We have obtained the energy spectra of α, *L*, and *M* groups in the primary cosmic radiation by the methods described. A possible interpretation of these spectra will be discussed briefly.

P4. Ionization Curves for Showers Produced in Various Absorbers by Intermediate Energy Electrons. ALAN ROSEN AND JOHN W. LINDNER, *Space Technology Laboratories.*—The effect of composition and thickness of the walls of an ionization chamber upon the ionization produced by an electron beam of intermediate energy was studied. The ionization chamber used was an aluminum-walled chamber filled with argon to a pressure of 200 lb/in². The electron beam was produced in the synchrotron at the University of California, Radiation Laboratory at Berkeley. Jackets of aluminum, iron, and lead were placed around the chamber and the ionization produced by beams of 26-, 99-, 196-, and 300-Mev electrons was measured as a function of absorber thickness and composition. Curves of these results were drawn and a comparison made with theory. These experiments were performed to determine if the current difference in identical ionization chambers shielded with walls of equal mass but different atomic number is sufficient to determine if an incident beam of charged particle radiation of unknown energy consists primarily of electrons or protons. The results showed that this could be done only for energies above 100 Mev.

P5. Fe^{59} Decay Scheme. J. M. FERGUSON, *U. S. Naval Radiological Defense Laboratory.*—The gamma-ray spectrum of 45-day Fe^{59} was investigated with scintillation detectors. In addition to the previously reported gamma rays at 0.19, 1.10, and 1.29 Mev, gamma rays at 0.14 and 0.33 Mev were observed. The positions of these gamma rays in the decay scheme is established from the gamma-ray energies and coincidence measurements. It is concluded that a level in Co^{59} at 1.43 Mev with a character of $\frac{1}{2}-$ is weakly excited by the Fe^{59} beta decay.

P6. Beta Decay of Rb^{87}.* G. B. BEARD AND W. H. KELLY, *Michigan State University.*—A 1-in. × ¾-in. NaI(Tl) crystal† containing a few tenths percent rubidium has been used to investigate the beta activity of Rb^{87}. The scintillation efficiency of the crystal for gamma rays was measured and found to be about 80% of that obtained using a comparison NaI(Tl) crystal grown under the same conditions. For the 662-kev Cs^{137} gamma ray, the resolution of the rubidium doped crystal was 13.6% compared to 12.4% for the undoped crystal. Measurements of the specific activities of small sections taken from the ingot both above and below the mounted crystal volume showed that the rubidium iodide added to the melt did not distribute evenly throughout the ingot. Therefore, a quantitative determination of the rubidium content in the crystal is necessary before the specific activity of the Rb^{87} can be calculated. Preliminary results of this and the beta spectrum analysis will be presented.

* This research was supported in part by the U. S. Air Force through the Air Force Office of Scientific Research of the Air Research and Development Command.
† Obtained from Levinthal Electronic Products, Inc.

P7. Search for "Vibrational" Levels in Nd^{144}.* C. A. MALLMANN AND F. T. PORTER. *Argonne National Laboratory.* The position of the second 2+ and 0+ and the first 4+ states in even-even nuclei is of interest in order to find more evidence for the (0,2,4+) vibrational triplet in certain regions intermediate between closed shells and regions of high nuclear deformation. $_{60}Nd^{144}$ levels are explored by the 3-Mev β^- decay of $Pr^{144}(0-)$. The well-known first 2+ state at 696 kev and the probably odd parity (1−) level at 2.19 Mev are the only obvious levels explored from the β^- side. We have made a search using coincidence and single measurements of the gamma rays in the Pr^{144}-Nd^{144} decay and find no evidence for population of the second 0+ or 2+ states. More quantitatively, if the usual beta-decay transition probabilities can be assumed, we rule out any second 2+ state below 1.5 Mev and any 0± or 1± levels below 2.6 Mev. The statement must of course be relaxed within 100 kev of the known 1− level at 2.19 Mev. Levels assigned 4+ and 6+ at 1.31 and 1.78 Mev, respectively, are explored from the (high spin) Pm^{144} electron capture decay. A level at 1.556 Mev has been inferred from gamma spectra following neutron capture in Nd^{143}. Our work would not rule this out as the second 2+ state. It appears that Nd^{144} does not show the "vibrational pattern" for various reasons.

* Based on work performed under the auspices of the U. S. Atomic Energy Commission.

P8. Natural Alpha Activity of Nd^{144}.* W. H. KELLY AND G. B. BEARD, *Michigan State University.*—The natural alpha

activity of Nd^{144} has been measured using a loaded liquid scintillator† containing 2% neodymium by weight. Preliminary results give a specific activity of about 4 counts per second per gram of Nd^{144}. This corresponds to a Nd^{144} half-life of 2×10^{15} years. The observed activity could also be accounted for by the presence of about 0.9% samarium as an impurity. However, the neodymium used in the scintillator has been analyzed and found to contain less than 0.01% samarium so that the presence of much samarium impurity is unlikely.

* This research was supported in part by the U. S. Air Force through the Air Force Office of Scientific Research and Development Command.
† Obtained from Nuclear Enterprises Ltd.

P9. Single Quantum Annihilation of Positrons.* ROY WEINSTEIN, *Massachusetts Institute of Technology.*—The annihilation of positrons via single quantum emission has been experimentally investigated using a 3-mc Na^{22} source, a large collection efficiency (3.5%) poor resolution beta spectrometer, NaI(Tl) gamma- and x-ray detectors, two differential discriminators and a 10^{-7} sec coincidence circuit. The need for large nuclear recoil momenta requires that the annihilation takes place with a K-shell electron. A coincidence is required between a gamma ray and a K x-ray of the proper energies. Initial data on Pb, Pt, Ta, and Al targets is consistent with $\sigma \propto Z^n$, where $n=5_{-1}^{+3}$. This rules out two quantum annihilation in the K shell, and agrees well with the expected Z^5 dependence. This salient feature of single quantum annihilation has not previously been observed.[1] The counting rate decreased as expected for x-ray energies above and below the K x-ray peak. The absolute magnitude of the cross section was evaluated to $\pm50\%$ at $E_\beta=400$ kev. Within experimental accuracy the results agree with the Jager-Hulme cross section.[2] The Born approximation cross section is clearly ruled out.

* This work is supported in part by funds provided by the U. S. Atomic Energy Commission, the Office of Naval Research and the Air Force Office of Scientific Research.
[1] J. A. Whalen, Bull. Am. Phys. Soc. Ser. II, **1**, 167 (1956). The report of Z^5 observation in this reference was premature. The work did show a decrease in the counting rate when the x-ray window was set above the K x-ray region. Hence single quantum annihilation was probably observed.
[2] J. C. Jager and H. R. Hulme, Proc. Cambridge Phil. Soc. **32**, 198 (1936).

FRIDAY AFTERNOON AT 2:00

Science Building 100

(M. A. BIONDI presiding)

Symposium of the Division of Electron Physics

Collision Processes

R1. Radiative Formation and Destruction of Negative Ions. L. M. BRANSCOMB, *National Bureau of Standards.* (30 min.)

R2. Electron Collisions with Hydrogen Atoms. W. L. FITE, *General Atomic.* (30 min.)

R3. Recent Electron-Beam Experiments for Measuring Excitation of Simple Atoms and Molecules. G. J. SCHULZ, *Westinghouse Research Laboratories.* (30 min.)

FRIDAY EVENING AT 7:00

Brooks Memorial Union

Banquet of the American Physical Society (Cocktail Party Preceding)

SATURDAY MORNING AT 10:00

Medical School Auditorium

(L. M. BRANSCOMB presiding)

Symposium of the Division of Electron Physics

Optical Pumping

S1. Some Recent Results on Magnetic Resonance of Excited States of Atoms. A. KASTLER, *Ecole Normale Superieure, Paris.* (30 min.)

S2. Optical Detection of Hyperfine Resonances in Rubidium and Cesium. E. BEATY, *National Bureau of Standards.* (30 min.)

S3. Spin-Exchange Resonance of Free Electrons. H. G. DEHMELT, *University of Washington.* (30 min.)

SATURDAY MORNING AT 10:00

Science Building 100

(A. G. BARKOW presiding)

Invited Paper

T1. High-Energy Physics with Bubble Chambers. W. D. WALKER, *University of Wisconsin.* (30 min.)

Apparatus of Nuclear Physics: Magnetic Resonance

T2. High Current Electrostatic Generators for Particle Accelerators. VICTOR WOUK, *Sorensen and Company, Inc.*—Electrostatic generators have been designed and built successfully employing a fundamental modification of the Van de Graaff principle, that allows a substantial increase in current rating. The modification basically is to employ a rotating insulating cylinder, rather than a belt, for transporting the charges from ground to the high voltage terminal. The cylinder allows for much greater linear speeds, and the controlled geometry permits much closer spacings of charging and discharging electrodes, smaller clearances to the voltage distributing devices, etc. The combined higher linear speeds and other factors, result in currents as high as 4 ma at 600 kv, in comparison to the usual Van de Graaff generator limit of approximately 1 ma. At 150 kv, 14 ma are obtainable. For high-resolution particle accelerator studies, stability of the order of 0.1% is achieved, in an extremely compact design, with no exposed high voltage points. The system operates at an insulating gas pressure of 20 atmos of pure, dry hydrogen.

T3. Mass Discrimination in Scintillation Detection.* R. L. BECKER AND J. A. BIGGERSTAFF, *University of Kentucky.*—The fluorescent decay of CsI(Tl) has been shown to be dependent upon the mass of the ionizing particle.[1] A scintillation spectrometer employs a CsI(Tl) phosphor, a DuMont 6467 phototube, and a multichannel pulse-height analyzer. With coincidence required between the integrated phototube output and an auxiliary signal indicating that the decay rate is within specified limits, relative masses of various groups may be determined. Deuterons of 650-kev energy provided the reactions $Be^9(d,p)$, $Be^9(d,t)$, $Be^9(d,\alpha)$, $B^{10}(d,p)$, and $B^{10}(d,\alpha)$ used as a test. The fluorescent decay of a single group of particles can be obtained with a resolution of 3%. Proton and α-particles groups are found to have decay rates differing by 6%, and either may be rejected while the other is being counted. Proton and triton groups have decay rates which differ by 2%.

* Performed under the auspices of the U. S. Atomic Energy Commission.
[1] Storey, Jack, and Ward, Proc. Phys. Soc. (London) **72**, 1 (1958).

T4. Liquid Xenon Scintillator for Gamma-Ray Detection.* H. W. KRUSE AND A. W. SCHARDT, *Los Alamos Scientific Laboratory.*—The scintillation properties of liquid xenon first described by Northrup *et al.* have been investigated by observing scintillations from 2 cm^3 of liquid. The xenon gas was first purified in a uranium furnace and then condensed in a quartz ampule the temperature of which could be controlled to ± 0.3°C in the range from -80 to -105°C. The scintillations were detected with a uv sensitive photomultiplier (K 1306); the amplifier had a 1-μsec clipping time constant. Relatively small pulse heights were observed without a wavelength shifter; however, with a diphenyl-stilbene coating on the inside of the ampule and Dow Corning 200 silicone fluid as optical coupling to the photomultiplier, the pulse heights for gamma rays were between 50 and 70% of those observed with a commercially canned NaI(Tl) crystal. Pulse-height spectra have been obtained for In^{114m} (92 kev) and Cs^{137} (662 kev) gamma rays as well as for Pu^{240} alpha particles (5.16 Mev). The best values for the resolution (full width at half-maximum of the full energy peak) are as follows: 16% for In^{114m}, 18% for Cs^{137} and 13% for Pu^{240}.

* Work performed under the auspices of the U. S. Atomic Energy Commission.

T5. Theory of a High-Resolution Beta-Ray Spectrometer with High Luminosity.* HERBERT DANIEL, *Iowa State College* (introduced by E. N. Jensen).—Second-order perturbation theory has been used to calculate the electron orbits in a "flat" beta-ray spectrometer with an azimuth-independent magnetic field having a symmetry plane. Abandoning first-order z focusing it is possible to obtain a much higher resolution at a given transmission compared with the usual $\pi\sqrt{2}$-instrument. The resolution depends, in the lower power, only on fourth-order terms of the radial and axial emission angles. The resolution does not depend on the first power of the source height. The focusing principle is applicable for a set of angles θ and the dispersion increases strongly with increasing angle. Several examples are discussed.

* Work was performed in the Ames Laboratory of the U. S. Atomic Energy Commission.

T6. Chlorine Nuclear Spin Lattice Relaxation Time.* P. A. BENDER, D. A. JENNINGS, AND W. H. TANTTILA, *University of Colorado.*—The chlorine nuclear spin-lattice relaxation time between pure quadrupole levels has been measured as a function of temperature in sodium chlorate and paradichlorobenzene. The technique used was that of pulsed nuclear induction using a nonsaturating pulse rather than a 90° pulse. The sample was saturated by repeated pulsing. The results are compared with Chang's theory[1] and found to be in good agreement. The Debye temperatures necessary to obtain a fit with Chang's theory are 200°K and 90°K for sodium chlorate and paradichlorobenzene respectively. The measurements were made in the temperature interval 10–300°K.

* Supported by a grant from the National Science Foundation.
[1] C. H. Chang, Office of Scientific Research reports available from Department of Physics, University of Washington, Seattle, Washington.

T7. Spin Resonance of Gamma Irradiated Albali Hydrides.* IAN SCARISBRICK, *The University of Michigan Willow Run Laboratories* (introduced by Chihiro Kikuchi).—The defect structure of the lithium lattice, which possesses both ionic and covalent character,[1] has been investigated by ESR and optical methods. The ESR of crystals colored by Co-60 gamma radiation has been examined at room temperature, 77°K and 4°K. At room temperature, two species of spin center are observable, both with $g = 2.0021 \pm 0.0003$ relative to an assumed value of 2.0036 for polycrystalline DPPH. One is produced only by high-gamma dosages and shows a 15% angular variation in width, which is less than three-quarters that of polycrystalline DPPH at room temperature. With low dosages, a line almost ten times broader is observed. At low temperatures, highly irradiated samples show both the sharp and broad lines, together with a third of higher g value. These and other results on irradiated crystalline LiH and also polycrystalline alkali hydrides and deuterides will be presented.

* This work supported by the Air Force Office of Scientific Research.
[1] D. H. Ewing and F. Seitz, Phys. Rev. **50**, 760 (1936).

T8. Relaxation Times for the Electron Spin Resonance of *F* Centers. GORDON A. NOBLE, *Zenith Radio Corporation.*—The magnetic resonance of F centers is inhomogeneously broadened. A theory of saturation for this case has been presented.[1] The saturation is measured at 300°K and 78°K for KCl crystals having a wide range of concentration. The derivative of the absorption is obtained using a 25-cps field modulation. At 78°K portions of the resonance where the sweep spends the most time and are more saturated. Hence the second harmonic component of the saturated resonance signal does not correspond to the second derivative of the unsaturated absorption. The relaxation time T_1 is measured directly at 4°K by first saturating a portion of the resonance, holding the field off resonance for a definite interval and then observing the resonance on the oscilloscope.[2] A "hot spot" about 10 gauss wide where reduced absorption occurs is retained in the resonance for 15 sec. The length of time can be understood considering the phonon distribution in potassium chloride.

[1] A. M. Portis, Phys. Rev. **91**, 1071 (1953); **104**, 584 (1956).
[2] Bloembergen, Purcell, and Pound, Phys. Rev. **73**, 629 (1948).

SATURDAY MORNING AT 10:00

Science Building 200

(T. A. ROUSE presiding)

Invited Papers

U1. Physics of Liquid Movement through Moist Sand. E. E. MILLER, *University of Wisconsin.* (30 min.)

U2. X-Ray Scattering from Macromolecular Systems. J. W. ANDERSON, *University of Wisconsin.* (30 min.)

General Physics

U3. Complete Frictional Stick-Slip Relation Cycle and Conditions for Onset of Major Wear. SELBY M. SKINNER AND EDWARD L. KERN, *Case Institute of Technology.**—The stick-slip cycle dynamical behavior is formulated exactly to take account of time-dependent adhesion, and to describe the complete relaxation cycle considering the dynamic behavior of both the slider and the sliding surface. The Bowden *et al.*[1] concept of a series of intermittent adhesions and breakfrees is utilized with the Bowden concept of adhesion commencing at a period of zero relative velocity. The formulation includes consideration of the mechanical constants of the slider support system and of the surface, which reduce to a set of three parameters entering into the equations for the dependence of the duration of stick upon the adhesion at breakfree. The adhesion appears in the final equations as a time-dependent function divided by the gross relative velocity of the slider and the moving surface. The nature of the dependence of the duration of stick, and of slip, upon the functional relationship between the adhesion and the time after commencement of stick is shown, and the range of functional relationships is indicated under which there is predicted the experimentally observed decrease of stick-slip behavior with increasing slider or surface velocity.

* With the support of the Office of Ordnance Research, U. S. Army.

[1] F. P. Bowden and K. E. W. Ridler, Proc. Roy. Soc. (London) **A154**, 640 (1936); F. P. Bowden and L. Leben, *ibid.*, **A169**, 371 (1939).

U4. The Effect of Copolymer Constituents on the Kinetics of Repetitive Contact Charging of Plastics. EDWARD L. KERN AND SELBY M. SKINNER, *Case Institute of Technology.**—Small amounts of comonomer constituents were added before polmerization to the monomers of the polymers previously reported; the charging by repetitive metal contact obeyed the same relationship, $V = V_f[1 - \exp(-nb)]$. As before, different metals yield different values of the charging parameter b; for any one metal, the effect of polymer composition is that given below. The copolymer constituents had little effect on the final potential, V_f, but a marked effect on the charging parameter b, and therefore on the initial rate of charging. Polymer preparation was by high purity methods, and incorporation of comonomer, polymerization, and all handling was done under lamp grade nitrogen. Methacrylic acid added to poly (methyl methacrylate) caused increase of b when in percentages up to 0.2%, and for higher percentages up to 5%, caused a decrease of b. The effect of acrylic acid is substantially greater than is that of methacrylic acid. Dichlorostyrene used as a comonomer with styrene decreased b rapidly, up to 0.1% concentration, without rise in value of b at higher concentrations. β-bromostyrene used similarly showed nearly the same effect. The dependence of the charging parameter b upon the chemical nature of the added material can be correlated with the initial charge observed on the sample before first contact.

* With the support of the Office of Ordnance Research, U. S. Army and the Manufacturing Chemists Association, Inc.

U5. Temperatures of Resumption of Molecular Motility in the Rewarming of Rapidly Frozen Aqueous Solutions.* B. J. LUYET, *American Foundation for Biological Research, Madison.*—Rapidly cooled aqueous solutions solidify into a transparent mass which, upon being rewarmed, becomes opaque at particular temperatures, as a result of a recrystallization made possible by the increase in molecular motility. Determinations made with solutions of some 20 substances of various kinds showed that the temperatures of recrystallization (1) change little with the concentration of the solute, (2) rise with increasing molecular weight of the solute, (3) occasionally undergo discontinuous changes with gradually changing solute concentrations. Thus: (1) A 1M sucrose solution recrystallizes at $-31.4°$, a 2M at $-31.8°$; (2) 50% glycerol, sucrose, and gelatin, at about $-65°$, $-32°$, and $-12°$, respectively; (3) 20 to 52% gelatin in the neighborhood of $-12°$, and 53 to 65% in the neighborhood of $-45°$. This behavior and other related phenomena suggest that the inhibition of molecular motility is attributable to the inertia of the solute rather than to modifications of the properties of the solvent, such as by a binding of its molecules, which would involve more specificity on the part of the solute.

* Work supported by the Office of Naval Research.

U6. Self-Adfustment of Integral Radiation Field to Compensate for Slowly Varying d Spacing in X-Ray Diffraction. H. COLE AND G. BROCK, *International Business Machines Research Laboratory, Poughkeepsie.*—When a single crystal slab, cut for symmetric Laue transmission diffraction, is elastically bent toward the x-ray source, the atomic planes fan out, producing a continuous change in d spacing through the crystal thickness. If one supposes that when the Bragg angle is correct for diffraction on the incident side, the internal radiation field will continuously adjust its angle of incidence (in the manner of light rays reflecting back and forth between two tilted mirrors) then, to first order, correct diffraction angles will be maintained throughout the region of slowly varying d spacing, and the exit beams will leave the crystal at a Bragg angle corresponding to the d spacing on the exit side. We have observed this "compensation" in the angle of the transmitted (forward diffracted) beam using "anomalous transmission" through certain 1 mm thick bars of dislocation free Ge, by placing the bent transmitting crystal in the first crystal position of a double crystal spectrometer. The sign and magnitude of the compensation angle is proportional to bend as expected in the tilted mirror analogy. This effect could provide a sensitive tool for studying creep, since the compensation angle would go to zero in time as the d spacing equalized front to back. Various anomalies in the integrated intensities and compensation angle in certain crystals indicate microstrains in the dislocation-free crystals.

U7. Specific Heat of Liquid Helium.* HARRY H. DENMAN, RYOICHI KIKUCHI, AND CHARLES L. SCHREIBER, *Wayne State University.*—Feynman[1] has applied his path-integral method

to liquid helium, and predicted the existence of a third-order phase transition. Kikuchi[2] has extended this work by the inclusion of geometrical correlation factors associated with an assumed cubic lattice structure, and found a second-order phase transition (the lambda point). However, the predicted specific heat did not exhibit correct qualitative behavior with temperature Only nearest neighbor permutations were considered. In the present work, the methods of Feynman and Kikuchi have been extended to include long range effects, and a new specific heat curve for liquid helium obtained. This result has all of the qualitative features of the experimental specific heat curve, and is proportional to T^3 near 0°K. The effective mass of helium is found to be 1.57 that of the helium atom.

* Work supported in part by the U. S. Signal Corps.
[1] R. P. Feynman, Phys. Rev. **91**, 1291 (1953).
[2] R. Kikuchi, Phys. Rev. **96**, 363 (1954).

U8. Heat of Chemisorption-Nitrogen on Tungsten. P. KISLIUK, *Bell Telephone Laboratories.*—The heat of adsorption of nitrogen on a tungsten ribbon has been measured calorimetrically. Over the range of low coverage where the sticking probability is sensibly constant, the value obtained is 4 ev/molecule. This is 20% less than the change in enthalpy of nitrogen adsorbed on similar ribbons computed from equilibrium adsorption isotherms. Thus the gas attains most of its binding energy within one second after adsorption at room temperature, but may move to a slightly more stable configuration at temperatures high enough for migration to take place at an appreciable rate. At higher coverages where the sticking probability falls off sharply, there is, on some ribbons, an unexpected increase in the heat of adsorption due to a small number of sites of high binding energy but low sticking probability.

U9. The Formation of Nitric Oxide in Strongly Shocked Air. J. J. ALLPORT, *Lockheed Missiles and Space Division.*—Observations of the formation of nitric oxide in strongly shocked air have confirmed the recent[1] theoretical calculations wherein it is predicted that the transient NO concentration far exceeds its equilibrium value. The concentration of nitric oxide was observed by the radiation from its characteristic vibratory frequency $V_0 = 1875.9$ cm^{-1}. The experiments were carried out in the Lockheed Missiles and Space Division 3-in. high-pressure shock tube. Nitric oxide formation was observed behind shocks in the Mach 8 to Mach 15 range with initial pressures (p_1) of dry, argon-free air of 10 mm and 5 mm of Hg. Collimating slits, an infrared transmitting window in the shock tube and two infrared transmission filters were used to isolate the radiation at $V_0 = 1875.9$ cm^{-1}. A liquid nitrogen-cooled indium antimonide detector was used to observe the radiation. After a shock of Mach 8.13 no overshoot in concentration was observed, the nitric oxide concentration growing slowly for 200 μsec. After shocks of Mach 11.0 and 14, overshoots of 11% and 100%, respectively, of the equilibrium concentration were observed.

[1] R. E. Duff and N. Davidson, Bull. Am. Phys. Soc. Ser. II, **4**, 195 (1959).

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Repeat of the Preliminary Announcement of the 1959 Honolulu Meeting

The 1959 Summer Meeting of the American Physical Society in the West is to be held at the University of Hawaii in Honolulu on Thursday, Friday, and Saturday, August 27, 28, and 29, 1959. The Department of Physics will be our host for the meetings, and sessions will be held on the campus. There will be symposia of invited papers on low-energy nuclear physics, high-energy nuclear physics, solid-state physics, resonance physics, theoretical physics, and atmospheric and cosmic-ray physics.

There are many hotels in Waikiki, of which the Princess Kaiulani Hotel will perhaps be the closest thing to an official hotel that we shall have: its rates are $12 for a single and $14 for a double room. Following are some of the others in the Waikiki area, and their rates: Moana Hotel, $12 single, $14 double; Islander Hotel, $5 to $8 single, $7.50 to $9.50 double; Edgewater-Reef Hotel, $7.50 to $9.50 single, $10 to $14 double; Waikiki Biltmore Hotel, $8 to $11 single, $12 to $18 double; Hawaiian Village, $10 to $16 single, $12 to $18 double. Taxis between Waikiki and the University cost about $1.20, irrespective of the number of passengers; there is also bus transportation. If you wish to stay at a hotel, write to it directly, and the sooner the better. Professor K. Watanabe is chairman of the Department of Physics, University of Hawaii, and Chairman of the Local Committee, and all general requests for information should be directed to him.

The journeys to Hawaii by sea is reputed to be delightful. Ships of the Matson Line sail from California every sixth day, and in particular on August 10 and 16 from Los Angeles and on August 22 from San Francisco. The journey takes four days and a half. There is a sailing of the American President Line from San Francisco on August 19 (and one from Hawaii on August 29). There are also airlines —among them, Pan American, United, Transocean, and U. S. Overseas from California, Northwest Orient from the Seattle area, Qantas Airways and Japan Airline from Vancouver. "Economy" flights are offered by Transocean and U. S. Overseas at least, perhaps by others. Bargain rates and "package tours" are said to be known to travel agents, who should be consulted.

Deadline-date for abstracts contributed to this meeting is Wednesday, July 1, and the abstracts must be sent to Professor W. A. Nierenberg, Department of Physics, University of California, Berkeley 4, California.

Preliminary Announcement of the 1959 Thanksgiving Meeting in Cleveland

Mandel Hall at the University of Chicago being unavailable at the time of our 1959 Thanksgiving meeting, we are interchanging our plans for 1959 and 1960. This year's Thanksgiving meeting will be held at the Case Institute of Technology in Cleveland, which with almost no notice has graciously accepted to receive us. Information about hotels will be published in the next (August) issue of this Bulletin.

Topical Conferences

Conference on Neutron Capture Reactions

A conference on neutron capture reactions will be held on October 1, 2, and 3, 1959 at Los Alamos, New Mexico. Any member of the Society who desires more detailed information must write to Dr. Henry T. Motz, Los Alamos Scientific Laboratory, Box 1663, Los Alamos, New Mexico. Abstracts of contributed papers may be sent to Dr. Motz (*not to the Secretary of the Society!*) and must reach him not later than August 7. Take note that it is the prerogative of the management of the Conference to accept or decline contributed papers that are offered.

1959 Gaseous Electronics Conference

The twelfth annual Gaseous Electronics Conference will be held at Washington, D. C., in the National Bureau of Standards, on October 14, 15, and 16, 1959. Invited papers at this Conference will center around "Collisions between Atomic Systems." Any member of the Society who desires more detailed information must write to the Secretary of the Conference, who is Dr. L. M. Branscomb, National Bureau of Standards, Washington 25, D. C. Abstracts of contributed papers may be sent to Dr. Branscomb (*not to the Secretary of the Society!*) and must reach him not later than August 29. Take note that it is the prerogative of the management of the Conference to accept or decline contributed papers that are offered.

Notice to Our British Members

The (British) Commissioners of Internal Revenue have approved the American Physical Society for the purposes of Section 16, Finance Act, 1958, and the whole of the annual subscription paid by a member who qualifies for relief under that Section will be allowable as a deduction from his emoluments assessable to (British) income tax under Schedule E.

Commencing with the year to April 5, 1959, a member who is assessable to income tax under Schedule E in respect of the emoluments of an office or employment is entitled to a deduction from those emoluments of the whole of the annual subscription which is due and payable by him to the Society in the income tax year provided that (a) the subscription is defrayed out of the emoluments of the office or employment, *and* (b) the activities of the Society so far as they are directed to . . . the advancement or spreading of knowledge (whether generally or among persons belonging to the same or similar professions or occupying the same or similar positions), are relevant to the office or employment, that is to say, the performance of the duties of the office or employment is directly affected by the knowledge concerned or involves the exercise of the profession concerned.

A Member of the Society who is entitled to the relief should apply to his tax office as soon as possible for form P 358 on which to make a claim for adjustment of his pay as you earn coding.

Proceedings of the American Physical Society

Minutes of the 1959 Annual Meeting Held at New York, January 28–31, 1959

THE 1959 Annual Meeting of The American Physical Society was held at New York City, in the Hotel New Yorker, the Governor Clinton Hotel, and the Manhattan Center, from Wednesday through Saturday, January 28–31. These were the habitations of the prior year, and the functions which recur at these Annual Meetings—the banquet, the Business Session, the Joint Ceremonial Session with the American Association of Physics Teachers (AAPT)—were set to recur at the same days and hours of the week. There was a swelling of nearly ten percent in the attendance, 3609 registered *versus* 3314 last year, and of course this year's figure is our all-time record. In the foregoing sentence, "our" must be taken as referring to American Physical Society and AAPT considered as one: the question of how to divide the credit for the registration between these two is scarcely even meaningful, and certainly we cannot answer it. Somehow the ten percent rise seemed to produce a more than ten percent fall in the amenity of the meeting: the surging masses, the stale air, the immense overcrowding at some of the sessions, and the lesser, yet still unpleasant, overcrowding at others, seemed definitely more oppressive than in 1958. As in 1958 so now it was our biggest hall (other than the Manhattan Center) which was most woefully inadequate to hold the multitudes who wanted to hear some of the most famous people and topics; but there was overcrowding elsewhere also, and we must weigh whether to hire larger halls at the cost not only of money but of our members' time, since larger halls are not to be found without going at least a few minutes' walk from our official hotel. At best, the big meetings are bound to lack many of the pleasant qualities of the small ones; and it is not a consolation to reflect that they are showing us "the shape of things to come." Everyone can see that the problems of managing a record meeting must be terrific, and all the greater should be our gratitude to Mrs. Emily Wolf of the American Institute of Physics who managed this one for us (and for the American Association of Physics Teachers). Mrs. Wolf had the collaboration of several others of the Institute's staff, who also deserve our compliments.

At the Joint Ceremonial Session of the Thursday afternoon, J. W. Beams delivered his Retiring Presidential Address "High-Speed Rotation." As always, this address was followed by the presentation of the Oersted Medal and by the delivery of the Richtmyer Lecture, both of these being features of the AAPT. The Oersted Medallist, Paul Kirkpatrick, responded with a speech entitled "On Colleagues and Clients"; the Richtmyer Lecturer, Charles Hard Townes, spoke under the title "Masers and Their Applications." Seldom if ever have we had three titles so succinct at the Joint Ceremonial Session.

The banquet of the two Societies was held on Friday evening; the attendance was 436, almost a match for last year's; the after-dinner speaker was H. L. Dryden of NASA, who opened to us almost unimaginable vistas of space exploration. After Dryden's speech, other voices spoke to us out of the film "Controlled Fusion" of the U. S. Atomic Energy Commission. Previously at the banquet the 1959 Oliver E. Buckley Solid-State Physics Prize had been conferred upon Conyers Herring.

There were 359 ten-minute papers at this meeting, 367 the year before, and 376 the year before that. The oppositeness of the trends of this figure and of the registration figure is surprising.

"At the Business Meeting of the Society, held on Wednesday afternoon, there was the usual scantiness of attendance, for which the officers can console themselves only by reflecting that there cannot be anything very wrong with the Society when no one comes to set it right." This sentence, quoted from the Minutes of the 1958 Annual Meeting, is valid also for the present Minutes. The results of the recent election were announced by the Chairman of the Board of Tellers (A. M. Weinberg). Of the six whom the Nominating Committee had chosen to compete with one another for the two posts on the Council for terms running from 1959 through 1962, Harvey Brooks and Charles Hard Townes outdistanced the others. The other officers elected on this occasion were: G. E. Uhlenbeck to be President; V. F. Weisskopf to be Vice-President; K. K. Darrow, S. L. Quimby, and S. A. Goudsmit, as heretofore, to be Secretary, Treasurer, and Managing Editor, respectively; and to the Board of Editors S. C. Brown, K. A. Brueckner, Frank Herman, G. E. Pake, J. L. Tuck, G. H. Vineyard (the foregoing with special assignment to *The Physical Review*) and John Bardeen and Robert Hofstadter (these with special assignment to *Reviews of Modern Physics*).

It has not been the custom to record in these Minutes the list of members lost through death which is read aloud at the Business Meeting. We shall mention, however, the figures on the list who were of particular significance to the Society as such. Of these the greatest in service was George B. Pegram, Treasurer of the Society for thirty-nine

years (1918–1957) and also a past President. Fortunately a tribute to him was published while he still was here to read it: it may be found in Volume 2, page 166, of this Bulletin. We have also to regret G. P. Brewington who managed two of our meetings at Detroit, and C. W. Heaps who managed three of them at Houston. Finally, by strange coincidence, we lost in the one year three members who so far as we know were the last survivors of the group that met on May 20, 1899, to organize The American Physical Society. They were Frederick Bedell, Bergen Davis, and Frank A. Waterman.

The Council met on the Tuesday preceding the meeting. One outcome of its deliberations has been displayed on page 302 of the Washington Bulletin: this is the detailed statement of the policy of sponsorship of "topical conferences." Another action of the Council was its formal acceptance of the responsibility for awarding biennially the Dannie Heineman Prize for Mathematical Physics, described on page 213 of the Washington Bulletin. Another was the reappointment of W. W. Havens, Jr., to the post of Deputy Secretary. Another, and the most painful, was the elevation of page charges to a new high—this because the Society was again sliding into the red, owing to the increase in cost of printing and to the increase in the quantity of articles to print. The increases are: in page charge, for articles in *The Physical Review*, $5 per page (to $30); in page charge, for letters in *Physical Review Letters*, $5 per page (to $35); and for abstracts printed in *Physical Review Letters*, $1 per abstract (to $8).

Forty candidates were elected to Fellowship and two hundred and ninety-nine to Membership: their names follow.

Elected to Fellowship on January 27, 1959: Robert L. Anthony, W. Carlisle Barber, Charles A. Barnes, Charles W. Beckett, Benjamin Bederson, Stephan Berko, Lawrence R. Bickford, Jr., Cornelius P. Browne, Nicolas Cabrera, Kenneth M. Case, William Carter Dash, Samuel N. Foner, John L. Gammel, Donald A. Glaser, G. Robert Gunther-Mohr, Paul V. C. Hough, Lloyd P. Hunter, Robert Jastrow, Karl G. Kessler, Samuel Krimm, Rolf W. Landauer, W. Wallace McCormick, Thomas R. McGuire, A. G. McNish, John W. Mihelich, Walter C. Miller, Robert W. Pidd, John S. Plaskett, Walter Ramberg, Charles A. Randall, Jr., Alfred G. Redfield, Mahendra S. Sodha, John Wescott Stewart, Robert M. Talley, Winfield W. Tyler, Richard F. Wallis, Satosi Watanabe, Walter D. Whitehead, Ralph A. Wolfe, and Donald R. Young.

Elected to Membership on January 27, 1959: Amikam Aharoni, *Nighat M. Ahmed, Frances S. Alsmiller, *Julian B. Andelman, Harold C. Anderson, Richard Anderson, Rafael Armenteros, John R. Asbridge, Frank H. Attix, *John Bahcall, Walter E. Baker, James B. Ball, Alan P. Batson, Charles W. Baulknight, *Richard C. Becker, *Johan B. Belinfante, Luc Berger, *Edward J. Bleser, Louis R. Bloom, *Joseph T. Bloxsom, Jacques M. Blum, Kjell Bockasten, M. H. Bortner, Keith Boyer, William E. Boyer, Daniel J. Bozich, Claude Brachet, Willis H. Braun, Maxwell H. Brennan, *Rodney A. Brooks, Edward A. Burke, Dwight C. Burnham, Gene A. Burns, Ernest G. Bylander, Samuel K. Cabeen, John H. Campbell, Robert Canada, Ferdinand F. Cap, Martin B. Cavanagh, Aparesh Chatterjee, *Yanglai Cho, *Deo C. Choudhury, Dean M. Christensen, Cao X. Chuan, C. Burleigh Cooper, *John M. Cornwall, *Lee J. Cuddy, *Harvey V. Culbert, Leland E. Cunningham, Robert L. Daniels, William B. Daniels, *W. Ross Datars, *K. T. R. Davies, Rui P. de Figueiredo, André N. de Nercy, *Bipin R. Desai, John T. Doherty, John R. Dorsey, *Joseph F. Dreitlein, Ronald W. P. Drever, Philip J. Duke, Charles H. Duncan, Bernard J. Dunn, *Alan C. Eckert, Jr., Allan R. Emery, *Viktor Evtuhov, Herbert E. Farmer, L. Dwight Farringer, Harold A. Feiveson, *Henry R. Feldman, Joseph M. Ferguson, *Thornton R. Fisher, Benson T. Fogle, Mario E. Foglio, Luciano Fonda, *William F. Ford, L. Curtis Foster, William Frederick, Jacques Friedel, Leslie S. Frost, *Charles R. Fuslier, Gary H. Gambrell, Edward E. Gardner, William A. Garee, J. Richard Garnham, Edward L. Garwin, *Richard W. Genberg, *Robert C. Gesteland, *Stanley S. Glickstein, Henry Goldberg, *David E. Golden, *Ronald B. Goldner, *Raymond Goldstein, Sanders Goldstein, Klaus Gottstein, Jack D. Graybeal, David Harrison Green, Leo Gross, Eugene Haddad, *Donald Halford, John P. Hallowes, Jr., John S. Handloser, Niels J. Hansen, Francis D. Harrington, *Rodney E. Harrington, *David L. Harris, Thomas A. Harwood, Walter G. Henderson, Everett D. Hinkley, Jr., *Alan T. Hirshfeld, *Duane A. Hockensmith, Gerhard W. Hoehler, *Dennis Holliday, *Henry B. Hollinger, *Donald D. Hollister, *Margaretta Hammel, I. L. Hopkins, Adelore L. Houde, *David P. Hutchinson, *Robert W. Ilgenfritz, *Neil R. Isenor, Robert E. Ives, *Kalkunte Iyengar, Arthur R. Jackson, *Jack Jaffe, Jean L. C. Jeener, Donald E. Jefferson, Oleg Jefimenko, *David A. Jerde, Harold A. Johnson, *David W. H. Joseph, Frank A. Junga, Kalman Kaliksten, Terry Kammash, M. Nathan Kaplan, Alfred K. Keast, William P. Keeney, *Faqir Chand Khanna, Edwin M. Kinderman, David L. Kingston, Claude A. Klein, Everett E. Klontz, *John W. Koch, Masahiro Kodama, Toyoki Koga, *Henry L. J. Kohn, Jr., Anthony J. Kolk, Jr., Martin R. Kramer, Alfred Kremheller, John C. Kudar, N. Kunitomi, *Thaddeus F. Kycia, Earl D. Kurtz, *Alexander Lande, Joseph V. Laukonis, Margaret E. Law, Jong Gu Lee, Richard L. Liboff, *Robert J. Liefeld, *Endre Lillethun, *William R. Limberis, Cole W. Litton, John S. Luce, Ronald E. MacDonald Masaharu Machida, *Isaac Maleh Alexei A. Maradudin, Norman H. March, Robert H. Marchessault, Keith W. Marlow, F. F. Marmo, *Bruce B. Marsh, John F. Marshall, Wesley K. Masenten, Noboru Matsudaira, Kurt Meetz, *Jack Menes, James S. Mills, Eliezer Mishkin, Crighton M. Mitchell, John B. Moffat, Cecilia Mossin-Kotin, W. F. Mruk, Edmund A. Nawrocki, John J. Nichol, Morikazu Nomoto, *Paul Nordin, Walter M. Nunn, Jr., Mary C. M. O'Brien, Robert S. Ohanesian, Sekyu Ohh, Kazuto Okamoto, G. D. O'Kelley, Philippe B. Olmer, Otto A. Ondroczky, *James B. Ott, *Lawrence L. Parker, David A. Patterson, Luisa B. Peraldo, *Edward L. Petersen, Ronald G. Peterson, *E. Gale Pewitt, A. G. Davis Philip, *C. Ballard Pierce, *Lewis S. Pilcher, *James N. Pinkerton, Pierre A. Piroué, Michael Poleshuk, Herman Pollak, Evert J. Post, *Ralph L. Preston, Clarence E. Prince, Jr., Ronald F. Probstein, *Philip L. Read, Robert G. Regenos, Harry C. Reifel, George W. Reiland, *John C. Reynolds, Thurman J. Reynolds, Forrest A. Rhoads, *J. Ivan Rhode, Billy L. Rhodes, Peter J. Richetta, *Peter Riley, *Kenneth Rind, *Nathan R. Roberson, Jr., David M. Rockmore, John P. Tomanoski, Anda M. Rosen, *Joseph E. Rothberg, Ronald V. Row, *John H. Rugheimer, *Thomas D. Sachs, Raymond R. Sawyer, Murray Scheibe, Harold L. Schenk, Jr., *Robert Schenter, Anthony P. Schmid, Jr., Kurt Schmidt, *Harold Schonhorn, Ariel G. Schrodt, Robert D. Sears, Norbert Segard, Donald P. Sera-

phim, John J. Sharer, [a]Basant L. Sharma, Herbert J. Shaw, Addison C. Sheckler, Arthur E. Sherman, Marion P. Shuler, Jr., Gail D. Smith, Kenneth F. Smith, [a]Raymond F. Snipes, [a]Walter R. Sooy, K. F. Sterrett, [a]Samuel R. Stone, III, [a]Richard N. Strayer, [a]Joe D. Stuart, Ryoki Suzuki, Lucia Tallone, Leonard S. Taylor, [a]Partick Thaddeus, Arnold M. Toxen, [a]Joseph H. Tu, [a]Ben Turner, J. Dale Turner, [a]Henry Unruh, Jr., Daniel J. Van Antwerp, [a]James D. van Putten, Jr., Theoddore D. Violett, John L. Vossen, Jr., Thomas Vrebalovich, Peter H. Wackman, Lothar Wandinger, Edel Wasserman, [a]Terence L. Watts, Erich S. Weibel, Robert S. Weisz, F. Oliver Westfall, Walter L. Whirry, F. A. Wierum, Jr., [a]Daniel Wilson, L. Woltjer, [a]Robert M. Woods, Jr., Robert M. Worlock, [a]Benjamin J. Woznick, F. H. Wright, Henry F. Yankov, [a]Shu-hsiung Yeh, Daniel M. Young, Russell D. Young, [a]W. Bruce Zimmerman, [a]J. Joseph Coyne, Hermann J. Donnert, Armando Agnati, [a]Elliot Bogart, Brian H. Flowers, [a]Steven W. Matthysse, and [a]James H. Vignos.

[a] Student.

Errata Pertaining to Abstracts H11, M7, N1, PA11, S5, SP1, V2, and Z11 of the 1959 New York Bulletin

(Series II, Vol. 4, No. 1, Part 1)

H11, by A. Pevsner, F. Anderson, M. M. Block, B. Brucker, I. Hughes, T. Kikuchi, C. Meltzer, H. Cohn, E. Harth, and J. Leitner. In line 6, instead of "(±2°)" read "(±12°)." Also in line 6, instead of "0.62±0.08 cm" read "0.62±0.08 mm." In line 8, instead of "0.60 cm" read "0.60 mm."

M7, by J. A. Harvey, R. C. Block, and G. G. Slaughter. In line 11, instead of "Am^{240}" read "Am^{241}."

N1, by D. P. Miller and M. E. Jones. Add "Data indicating the existence of noncubic forms of cubic semiconductors have instead been found to be due to iron and chromium contamination of the copper x-ray tube target."

PA11, by P. L. Auer and H. Hurwitz, Jr. In lines 13 and 14, instead of "limit equals $-\mu B$ plus the rms value of $(m/2)(cEXB/B^2)^2$, where μ is the adiabatic invariant magnetic moment" read "limit equals the average value of $(m/2)(cExB/B^2)^2$." In lines 16 and 17 instead "oscillates in time with frequency ω" read "oscillates in time with frequency ω, and μ is the adiabatic invariant magnetic moment."

S5, by Eugene Guth. In line 16, instead of "close collisions" read "distant collisions." In line 17, instead of "distant collisions" read "close collisions."

SP1, by E. J. Schremp. In line 4, instead of "$\psi_+(x)+q(x)\psi_+(0)$" read "$\psi_+(x)=q(x)\psi_+(0)$." In line 10, instead of "fere-particle" read "free particle." In line 19, instead of "$\|\nu\gamma_5\nu^c\|$" read "$\|\nu\ \gamma_5\nu^c\|$."

V2, by H. G. Blosser. Add at end "all dimensions given above for radical stability limits should be increased by Factor of two."

Z11, by Morris Salkoff and Ernest Bauer. In lines 4 and 5, instead of "our result, in the form of Blackman,[2]" read "our result, in the form of a vibrational relaxation time, has been compared with the experimental results of Blackman,[2]."

Minutes of the 1959 Southwestern Meeting Held at Austin, Texas, March 6–7, 1959

THE 1959 Southwestern Meeting of The American Physical Society was simply delightful, and to those who attended both it and the 1959 Annual Meeting the memory of the earlier one caused positive pain, so bleak was the contrast between its congestion and the spacious circumstances at Austin. The scientific sessions were held at the University of Texas, in the Batts Auditorium and the Physics Building, both of them close to the imposing central tower of the University. The walk between the hotels and the meeting places was of just the right length, and the weather was conducive to enjoying the out-of-doors as well as the indoors. Since the whole attendance (that is to say, the attendance as measured by the registration) was only 240, no hall was ever overcrowded or even crowded. It is a tragic paradox that our conventions, and probably not ours only, must be small to be agreeable. With 70 contributed papers and 21 invited papers, we could not avoid simultaneity of sessions, but we could minimize coincidences between papers of similar topic. Most of the papers came from institutions of Texas, and next most largely represented were the University of Oklahoma and the Los Alamos Scientific Laboratory; but there were speakers from much further afield, as far as Massachusetts in the Northeast, California in the West, and Mexico in the South. The diversity of topics was almost as great as in our "big" meetings, though the distribution showed marked signs of local interests—atomic and molecular spectra, gaseous electronics, and nuclear reactions were relatively more abundant than at the meetings in the East.

Early on the Friday evening there was a cocktail party in the Maximilian Room of the Driskill Hotel: this we owe to the generosity of Texas Nuclear Corporation and Texas Research Associates Corporation: it was highly appreciated. Immediately thereafter followed the banquet of

the Society, in the Crystal Room of the same hotel. This was unusually good both in the quality of the after-dinner speeches and in the quality of what came before. Dean Hagerty welcomed us to the University of Texas, A. von Engel convulsed us with laughter, and J. C. Morris delivered the principal speech of the evening (which it is hoped will appear in *Physics Today*). From the hands of W. V. Houston, the President and the Secretary received diplomas describing them as honorary citizens of Texas. The attendance at the banquet —was 185, which comes to a remarkably high percentage of the registration.

Since there was no Council meeting on this occasion, there is no list of elections to membership to be appended; and this brief report may close as it should, with an expression of warm thanks to those who helped with the meeting—above all, to Professor C. W. Horton the Chairman of the Local Committee, and Mrs. Horton who arranged the ladies' luncheon and style show of which we hear most favorable accounts.

Minutes of the 1959 "March" Meeting Held at Cambridge, March 30–April 2, 1959

IT is a curiosity of our major meetings that in respect of number of contributed papers they remain nearly constant for several years at a time, and then take a sudden upward bound. This happened some years ago to the Annual Meeting, and in this year of 1959 it has happened to the Spring Meeting and to the "March" Meeting. We call this the "March" meeting in quotes, although it extended into April and the Southwestern meeting was wholly in March: it was, of course, that annual meeting at which the Divisions of High-Polymer Physics, Solid-State Physics, and Chemical Physics dominate the scene. There were 323 ten-minute papers, and the previous record was 260. Even more striking was the upward bound in attendance: the previous best registration was 1088, this year it was 1409. It is tempting to ascribe this great gain to the attractiveness of Cambridge, but the Secretary is of the opinion that the credit must be shared with other causes: general expansion of interest in solid-state physics for one, and energetic initiative on the part of the Division of Chemical Physics for another.

The Massachusetts Institute of Technology was an admirable host. Nowhere are the halls for our sessions more numerous or better, and the distances from hall to hall were just enough to provide welcome exercise. We are sorry that our meetings at M.I.T. are not annual events, but this sorrow is probably not shared by John C. Slater and George Harvey, the skillful and hard-working heads of our Local Committee

The banquet was held on Tuesday evening in the M.I.T. Faculty Club. It was not merely an exceptional, it was a *unique* combination of high quality and low price. The after-dinner speakers were P. P. Ewald and E. R. Fitzgerald. The attendance, as usual, was disappointingly low. Only 240 turned up to partake of one of the best dinners to be had in the Boston area that night. The cocktail party of the previous day was better attended.

At a brief meeting of the Council, 301 candidates were elected to Membership and 23 to Fellowship: their names are appended.

Elected to Fellowship on April 1, 1959: Henri Amar, Isadore Amdur, Norman Austern, M. A. Biondi, T. M. Donahue, R. G. Fowler, G. M. Frye Jr., Frederic Keffer, J. J. Lambe, J. A. McIntyre, F. R. Metzger, David Mintzer, Roger Newman, H. C. Paxton, A. V. Phelps, D. C. Ralph, D. J. Rose, Marshall Rosenbluth, L. J. Varnerin Jr., G. P. Wachtell, H. G. F. Wilsdorf, W. E. Wright, Chia-Shun Yuh.

Elected to Membership April 1, 1959: David Abraham, Willard P. Acheson, Albert W. Adey, Kessar D. Alexopoulos, *A. Guerrero Almonacid, Donald P. Ames, Allan Anderman, David H. Anderson, *R. Lester Anderson, Warren Anderson, *Martin Ashkin, Ernest N. Ashley, Jr., *Leland J. Barnes, T. H. K. Barron, Robert T. Bate, Allan F. Beck, Ralph Sherman Becker, *Everet H. Beckner, *Edward Lee Beeson, Jr., *Jerry Alan Bell, S. Bayne Bentley, *Eugene V. Benton, J. L. Bergsteinson, *Richard J. Berkely, *Charles V. Berney, James R. Best, Donald L. Birx, *Allen G. Blair, *S. Leslie Blatt, *H. Richard Blieden, *Uldis Blukis, James H. Bly, Wm. G. Brammer, Sol R. Brandell, Jacob D. Broder, Richard N. Brown, William G. Browne, William C. Bryan, Gary T. Budris, Stanley Bumble, Garrett J. Busselman, Joe W. Cable, Ulrich Cappeller, K. S. W. Champion, Richard C. Chase, *Mao Chao Chen, Laura M. Cheng, *Paul Cherin, Roderick Chisholm, *Daphne S. Christensen, Michael Cohen, William R. Cole, John A. Cowan, *Richard A. Craig, Paul A. Crandell, *Cornelius J. Creedon, Daniel J. Crowley, Jr., *Ashley A. Cunningham, J. Richard Cunningham, Jr., Alexander J. Curtis, *Max Daehler, Spero A. Dalietos, *William J. Dambeck, Bruce R. Danner, Leo R. Davis, George M. Di Giacomo, E. Roland Dobbs, Kermit E. Duckett, *Cornelis Dullemond, Thomas G. Dunne, Donald F. Eagle, *William S. Edwards, Jr., Theodore G. Elser, *Robert P. Ely, Jr., Joseph F. Ferrante, Alfred E. Feuersanger, C. Dudley Fitz, Joseph M. Flaherty, Robert A. Florentine, Paul Y. Feng, *Kenneth Fox, Richard St. Clair Fowkes, Harlow Freitag, Hideya Gamo, Robert T. Garcia, *Arthur F. Garfinkel, *Victor Gilinsky, Frederick Gilligan, *Carol Z. Golden, Herbert Goldsmith, Robert A. Goldstein, *John M. Goodkind, Roman J. Gostkiewicz, Glenn A. Greathouse, Reynold Greenstone, *Jane M. Hall, David P. Hamblen, Norbert N. Hankin, *Robert A. Harris, Thomas S. Hartwick, *Alan F. Haught, Oscar G. Hauser, Edvard Heiberg, Patricia A. Hertzler, George G. Herzl, Leonard F. Herzog, II, Lawrence Himmel, Merle N. Hirsh, *Morton Z. Hoffman, *Daniel W. Hone, C. Richard Honeycutt, W. Wallace Hunt, Jr., *Chester F. Hwang, Otto K. Husmann,

Stephen K. Ichiki, *Richard L. Jacob, *A. Keith Jameson, John Jarem, Donald W. Jepsen, *Robert A. Johnson, Richard E. Johnston, John E. Jordan, *C. Miller Jones, Fritz R. Kalhammer, Rudolf E. Kalman, *Morton Kaplan, *Will S. Kendall, Roger C. Kennedy, *Sanford Kern, William L. Kester, John Killeen, Jae Kwan Kim, *Michael W. Klein, *Leonard Kleinman, *Andrei Konradi, Lester Kraus, Hermann G. Kummel, *Kwan Wu Lai, John W. Layman, Raymond LeBlanc, *Myron Lecar, John V. Lee, *Kenneth Lee, Donald Leibowitz, Martin Lessen, *Jerome Liner, *Eldred B. Littlefield, Albert E. Lombard, Jr., Maurice W. Long, Gerhart Luders, Giunio Luzzatto, S. W. MacDowell, Julius L. Mack, Koichi Mano, *Robert H. March, *Theodore Marshall, Walter C. Marshall, Stephen H. Maslen, T. B. Massalski, Ludwig J. Mayer, Bruce McCarroll, *Terence E. McEnally, Jr., *Wm F. McGee, *James A. McKee, Donald W. McKinney, Dane A. McNeill, *Donald A. McQuarrie, Saul Meiboom, James E. Mentall, Richard F. Merian, J. Horst M. Meyer, Frank Curtis Michel, *Francis J. Miller, G. Lorimen Miller, Clark D. Mollenhauer, *Thomas W. Moore, Masato Morita, Forrest S. Mortimer, Donald C. Murray, Narendra Nath, Walter J. Neidhardt, *Nikola M. Nikloic, Edwin Norbeck, Jr., John W. Northrip, *Thomas F. O'Malley, Tore Olsen, Yuzuru Ooshika, *Howard S. Ostrowsky, Lorne A. Page, *Leigh Hunt Palmer, *Emmanuel P. Papadakis, *Paul B. Parks, Herbert Payne, Herbert N. Pedersen, *Erik C. B. Pederson, George E. Pellissier, *John P. Penhune, John A. Perri, Laurence E. Peterson, Henri T. Pichal, Elizabeth H. Plassmann, *Charles A. Plumeau, William E. Price, Hans Primas, Agnar Pytte, Martin F. Rafter, Joseph L. Randall, Olaf N. Rask, *David M. Raybin, Joseph B. Reagan, *Paul L. Reeder, *Walter Reichelt, *Robert E. Reynolds, Franklin J. Rhoads, John L. Richter, *Franklin A. Robben, John L. Rodda, Alan Rosen, *Erhard W. Rothe, *Herbert L. Rothman, *Harvey Rubinstein, *Keiser H. Ruei, Robert A. Ruehrwein, Enrique Salz, *A. G. Sadasiv, Claude St-Pierre, *Edmundo Sandoval-Sandoval, Vincent A. Santarelli, Mykola Saporoschenko, *Michael M. Schlacter, Jr., Alfred Schock, *Martin C. Schumacher, Allen B. Scott, Kenneth W. Scott, *Peter L. Scott, Adolph Selzer, Robert E. Shafer, *Morris Shatzkes, Arthur Sherman, Theodore S. Shilliday, Willem J. Siemons, *Joseph D. Silverstein, Daniel M. Smith, *John H. Smith, Mary E. Smith, William A. Smyth, Nathan W. Snyder, Raymond Solomon, *Frank Spagnolo, *Richard M. Spector, John R. Spreiter, *Esther L. Sprenkel, Harold A. Spuhler, *Thomas E. Stark, Norman J. Stevens, John R. Stokes, Chester G. Storruste, Jan C. Stryland, Rubin N. Summergrad, Donald L. Summers, *Jan Tarski, Richard B. Theus, George H. Thiess, Hans J. Tiller, David R. Tilley, Jacques G. Tillieu, *F. S. Timson, Reuben S. Title, *Paul D. Toft, *Charles R. Troutman, *Ernest W. Valyocsik, *Libor J. Velinsky, George Veronis, Erich Vogt, Robert C. Waddell, C. J. Waddington, Howard W. Wagenblast, *C. Thomas Walker, Robert Wallace, Jr., Robert D. Wanselow, *Edward L. Waters, R. D. Weglein, A. Weinmann, Glenn C. Werth, *Donald H. White, Paul S. White, Jr., Richard M. White, Franz J. Wilhelm, *Stanley A. Williams, A. B. Willoughby, George B. Wilmot, Larry K. Wilson, *Stanley H. Wineland, Albert B. Wing, M. C. Wittels, *John H. Wolfe Raymond Wolfe, *Van Earl Wood, John R. Wormald, *James P. Wright, and Philip G. Youngner.

* Student.

Errata Pertaining to Abstracts D11, NA5, and Q10 of the 1959 Cambridge Meeting

(Series II, Vol. 4, No. 3)

D11, by T. Matsuo and T. T. Sugihara. In lines 1 and 2, instead of "The ratio of sections" read "The ratio of cross sections." In Table I, the heading "Mean alpha energy in thin target (Mev)" should be below the first double line in the table. Also in Table I, the last line on the left, instead of "(15%)" read "(±5%)."

NA5, by P. E. Wigen, J. A. Cowen, and Paul A. Parker. The displayed equation should read:

$$\mathcal{H}=\beta_e \mathbf{S}\cdot g\cdot \mathbf{H}+2\gamma\beta_e\beta_n\left[\frac{\mathbf{S}\cdot\mathbf{I}}{r^3}+3\frac{\mathbf{S}\cdot\mathbf{r}\mathbf{r}\cdot\mathbf{I}}{r^5}+\frac{8\pi}{3}(\mathbf{S}\cdot B\cdot\mathbf{I})\right].$$

Q10, by Alan Schoen. This abstract was withdrawn by the author but inadvertently left in the Bulletin.

Minutes of the Spring Meeting of The Ohio Section of The American Physical Society, Held at Capital University, Columbus, Ohio, on April 17–18, 1959

THE regular Spring Meeting of the Ohio Section of The American Physical Society was held in joint session with the Section E—Physics and Astronomy—Ohio Academy of Science, at Capital University, Columbus, Ohio, on Friday and Saturday, April 18–19, 1959.

Friday morning was spent in viewing and in rating the physics projects submitted by high school students in the Science Day program of the state. The final competition was limited this year, producing a decided improvement in the quality of the work seen at this time. The physics category continues to be the subject of a larger fraction of the projects than any other area.

The Friday afternoon program was devoted to bringing the current work on the Thermonuclear Problem to our Ohio Section. The recently released USAEC color film on "Research in Controlled Fusion" was shown. This was followed by two invited papers: "The Princeton Stellarator" by Dr. Katherine M. Weimer, of the Matterhorn Project, Princeton University, Princeton, New Jersey; and "The Oak Ridge DC-X" by Dr. Rabhael A. Dandl, of The Oak Ridge National Laboratory.

On Saturday morning, twelve contributed papers were presented, three of them being: "A Special Course for Secondary School Teachers of Science," by William Riley, The Ohio State University, Columbus, Ohio; "The Battelle Research Reactor" by A. M. Plummer, J. N. Anno, and J. W. Chas-

tain, Battelle Memorial Institute, Columbus, Ohio; and "Description of Battelle Shielding Research Facility," by W. R. Morgan, R. K. Klingensmith, and H. M. Epstein, of the Battelle Memorial Institute, Columbus, Ohio. Abstracts of the nine contributed papers representing reports of research work in progress follow below.

This being the annual business meeting, the following officers were elected to serve for the year 1959–60. Dr. M. Eugene Merchant, Research Director, Cincinnati Milling Machine Company, Cincinnati, Ohio, to be Chairman; Dr. Albert B. Stewart, Antioch College, Yellow Springs, Ohio, to be the Vice-Chairman; and Leon E. Smith, Denison University, Granville Ohio, to be the Secretary-Treasurer. The fall meeting was scheduled to be held at Kent State University, Kent, Ohio, on October 16–17, 1959.

On Saturday afternoon, the men from the Battelle Memorial Institute Staff, Dr. William Ballou, Mr. W. R. Morgan, and Mr. A. M. Plummer arranged and conducted a tour of the Battelle Memorial Institute's 2-megawatt reactor located at West Jefferson, Ohio.

The attendance at this program was exceptionally large on both days.

LEON E. SMITH, *Secretary*
Ohio Section
Denison University
Granville, Ohio

1. Some Results of Fallout Measurements in Columbus, Ohio. MARSHALL KREITMAN, *The Ohio State University.*—A study of the fission products detected in certain radioactive air samples has been made. A number of specific radioactive isotopes have been verified and observed in several particular air samples over a six-month period with a 100-channel analyzer using a 3-in. well-type sodium iodide crystal. Some of these isotopes, their half-lives and gamma ray emission energies, are respectively as follows: Ce^{144}, 290 days, 0.134 Mev; Ce^{141}, 32.8 days, 0.142 Mev; Ru^{103}, 39.8 days, 0.498 Mev; Nd^{147}, 11.3 days, 0.092 Mev; Zr^{95}, 65 days, 0.72 Mev; and Nb^{95}, 35 days, 0.764 Mev. A geiger counter scalar unit has been used to measure the beta activity of the samples exposed 24 hours or longer and collected during the past 22 months (May 1957 to April 1959). The results of these observations, including the recorded peaks of activity during this period and a description and comparison of the two air samplers and air filters which were used to collect the activity from the air, are to be presented.

2. Measurement of Radioactivity in the Environment. G. R. HAGEE, *United States Public Health Service.*—For the measurement of radioactivity in various environmental media a variety of electronic instruments are employed. The Robert A. Taft Sanitary Engineering Center has instrumentation in two separate counting rooms for this purpose; one for gross alpha and alpha plus beta activity determinations, the other for very low-level specific radionuclide counting. Gross activity measurements are made with internal gas flow proportional counters, or alpha scintillation counters. A low-level counting facility houses specialized equipment including a low-background (anticoincidence) beta counter, a low-level gamma spectrometer using a heavily shielded 4-in.×4-in. NaI(Tl) crystal and 100-channel pulse-height analyzer, a liquid scintillation spectrometer, and other beta counters and gamma spectrometers. A 4π-beta proportional counter is also available for nuclide standardization. The applications of each of these instruments and their sensitivity and utility in this field are discussed.

3. Application of Bernoulli's Theorem to the "Teapot Effect." G. P. CHOTKEVYS, *Western Reserve University* (introduced by P. R. Zilsel).—The Teapot Effect has been described by Reiner.[1] We performed experiments to test a possible explanation: because of the viscosity of the liquid, a velocity gradient exists across the stream as it emerges from the spout, the velocity being greatest at the front. By virtue of the viscous drag on the air layer adjacent to the stream, this produces a differential air pressure tending to push the stream backward, similar to the case of the "spinning baseball." We have been measuring velocity profiles by observing the wavelengths of standing capillary waves generated on the surface of the stream. Preliminary results indicate that a velocity gradient does in fact exist, but may not be large enough to account for the Teapot Effect.

[1] M. Reiner, Phys. Today **9**, 16 (September, 1956).

4. Analog Computer Simulation of a Parametric Amplifier. M. HOROWITZ AND N. D. DIAMANTIDES, *Goodyear Aircraft Corporation.*—An analog computer has been used to simulate a parametric amplifier.[1] The circuit simulated is an *RLC* series circuit where C varies. An input signal of 2 cps is applied in the form of charge added to the capacitor's plates. The amplified output is represented by the total charge. Recordings from the computer are given for $\Delta C/C=0.1$ and for variable damping. Amplification of a low-level signal was observed.

[1] W. E. Danielson, J. Appl. Phys. **30**, 8 (1959).

5. An Investigation of the Vapor Phase of $CoCl_2$. K. E. GLICK AND T. S. SMITH, *Ohio University.*—The vapor pressures of $CoCl_2$ at various temperatures have been measured by two different methods, the transpiration method and the boiling point method. In each case, the data were assumed to fit a straight line of the form $\log p=(A/T)+B$, where p is the vapor pressure of $CoCl_2$ at the Kelvin temperature T. Equations of the lines were derived by applying the least squares method to the data. For the transpiration method, the constants are $A=-8.915$°K and $B=9.842$; while the boiling point method yields $A=-7.847$°K and $B=8.777$. Two calculations of the heat of vaporization were made, one from the slope of the transpiration line and one from the slope of the boiling point line, the values being 40.8 kcal/mole and 35.9 kcal/mole, respectively. The differences indicate that there is some association of the $CoCl_2$ vapor. An attempt was made to calculate the heat of association of the $CoCl_2$ molecules.

6. Oscillating Regions in the Argon Discharge.* ALBERT B. STEWART, DONALD MCCARTOR, JOHN LINK, AND STANLEY GOLDBERG, *Antioch College.*—The effects of anode size and of cathode surface on the audio-frequency oscillations in argon discharges have been studied. In one experiment an oxide coated hollow-nickel cathode was used, first heated (cathode fall=15 v), then, after cleaning and reassembling, as a cold nickel cathode (cathode fall=250 v). The voltage, current, plasma potential, and light oscillations, including the so-called negative striations, were as closely the same as in successive experiments holding the cathode conditions constant. In a second experiment a multiple anode tube was studied in both the subnormal discharge and at higher currents with moving

striations. In the subnormal region the frequency of the anode oscillations decreases as the area of the anode is increased. In the striated region, changing anode size has no effect on the oscillation frequency in the positive column. In a third experiment motion of the striations in the positive column was measured as the tube length was changed. The phase of the oscillations is determined by the distance of the observation point from the anode. An interpretation of these results in terms of three oscillating regions will be given.

* Supported by the National Science Foundation.

7. Pulse Length and Spectral Distribution of the GE FT30 Flashtube.* C. R. FINFGELD, *Western Reserve University.*—The GE FT30 Flashtube is capable of generating light pulses, in the visible region, of several microseconds duration, at a peak input power of approximately 500 w. By using a monochromator having a band pass of 30 A, the pulse length and the distribution of intensity as a function of wavelength has been investigated. It has been established that the pulse length remains constant at 2 μsec throughout the visible spectrum whereas the visible radiation has a maximum intensity at 600 A, and falls to half this intensity within 400 A.

* Work supported by U. S. Army Office of Ordnance Research.

8. Paramagnetic Resonance Spectrometer.* J. C. GILFERT AND BERNHARD M. SCHMIDT, *The Ohio State University.*—A spectrometer has been constructed for the study of paramagnetic resonance in the microwave region of 9300 Mc/sec. The instrument combines desirable features of several reported spectrometers in such a manner as to provide improved flexibility and ease of operation. A description of the instrument is given, along with several representative recordings of observed absorptions. A brief discussion on the factors currently limiting the sensitivity of the spectrometer is included to indicate the directions in which improvements can be realized.

* Supported in part by the C. F. Kettering Foundation and the Office of Naval Research.

9. Nuclear Emulsion Study of the $\pi-\mu-e$ Decay. ANDRIAS T. BARUS, *Miami University,* AND DAVID F. GRIFFING, *Oxford, Ohio.*—One-hundred seventy-two $\pi-\mu-e$ decay events were found in nuclear emulsions. The angular distribution of the emission direction of the energetic electron with respect to the initial μ-meson direction was determined. These data were fitted to a curve of the form $[I(\theta)d\theta \sim (1+\alpha\cos\theta)\sin\theta\, d\theta]$, where α is the asymmetry coefficient. A least squares analysis gives the value $\alpha=-(0.24\pm0.01)$ in agreement with the results of several other workers.

MEETINGS AND DEADLINES THROUGH JANUARY, 1960

Place	*Meeting dates*	*Deadline date*
Milwaukee, Wisconsin	June 18–20	past
Honolulu*	August 27–29	July 1
Chicago (?)	November 27–28	September 25
Pasadena*	December 28–30	October 23
New York	January 27–30, 1960	November 13

* Abstracts for the Honolulu and Pasadena meetings are to be sent to W. A. NIERENBERG, University of California, Berkely 4, California, and must reach his office not later than the corresponding deadline date. Abstracts for topical conferences are to be sent to the addresses given on page 331.

Abstracts for the other meetings listed above are to be sent to KARL K. DARROW, American Physical Society, Columbia University, New York 27, New York, and must reach his office not later than the corresponding deadline date. Take note that abstracts mailed the day before deadline day often fail to arrive in time: the last postal delivery of the day usually comes to our office before 2 P.M. Allow at least two days for abstracts sent by airmail from points east of the Mississippi, and longer for those sent from farther west. Abstracts postmarked (at the point of dispatch) on deadline day are instantly rejected, and telegrams heralding their arrival are fruitless except in revenue to the telegraph company. *The privilege of contributing papers to meetings of the American Physical Society is restricted to the members of the Society and to nonmembers whose papers are sponsored by members.*

TOPICAL CONFERENCES (see page 331)

Los Alamos	October 1–3	August 7
Washington	October 14–16	August 29

RULES AND INSTRUCTIONS FOR THE PREPARATION OF ABSTRACTS

The Council has ordered that abstracts shall be not longer than two hundred (200) words or the equivalent thereof. In reckoning equivalence, a footnote is equated to ten words; each line in a table to ten words; a "display" formula—one that requires a line to itself—is an expensive luxury equated to forty words.

Two copies of each abstract must be sent to the appropriate office. They must be typewritten; *one must be an original*, the other may be an original or a carbon copy. *Carbon copies will not be accepted in lieu of originals:* they smear. *Abstracts must be double-spaced:* single-spaced manuscripts are too crowded to permit the editorial markings to be made with ease and clearness. *Each abstract must be confined to a single page:* if it is too long for a single page it is too long to be printed. If we receive an abstract typed on two pages, we print only its first page. *Write each abstract as a single paragraph:* the suppression of paragraphs costs time and labor to the editors. *Do not use very thin paper:* a sheet of very thin paper may cause extraordinary trouble when mixed with sheets of reasonable thickness. The American Institute of Physics will bless you if you type first the title of your abstract in lower-case with capitalized initials, then your name in capitals, then the name of your institution in lower-case underlined. It is a pleasure to report that those who qualify for this blessing are increasing in number but are still quite a bit short of 100% of the total. Issues of the *Bulletin* are always appreciably delayed because the editors have to do what the authors should have done.

Remember the rule of the Council that, if an author submits more than one abstract, all but one must go onto the Supplementary Programme. In enforcing this rule, an abstract is credited to the author whose name appears first in the by-line.

It has now become an expensive business to make any change in an abstract, even the smallest, after the abstract has gone to press. By order of our Council "A change in an abstract will be permitted only at the discretion of the Secretary or his deputy, and only if TEN DOLLARS is enclosed with the letter in which the change is requested." As heretofore, an abstract will not be withdrawn from proof unless the asker sends ten dollars with his request.

Erratum Pertaining to the 1959 Washington Bulletin

(Series II, Vol. 4, No. 4)

(Proceedings of the meeting and errata for abstracts will appear in a later issue.)

Page 303, line 13 of second column, instead of "R. L. Hayward" read "R. W. Hayward."

Room Reservations on the Marquette Campus for the Milwaukee Meeting

To:

E. D. Berners
Physics Department
Marquette University
Milwaukee 3, Wisconsin

Please reserve the following accommodations on the Marquette campus (indicate the number of rooms requested):

.....rooms without bath in Walter Schroeder Hall for one person at $5 per day for June 17....., 18....., 19....., 20.....

.....rooms without bath in Walter Schroeder Hall for two persons at $6 per day for June 17....., 18....., 19....., 20.....

If you wish to share a double room in Walter Schroeder Hall with a person who is making a separate request for a reservation, please give his name .....

.....

.....units in Bonifas Hall at $5 per day for ..... persons for June 17....., 18....., 19....., 20.....

I would like parking space at Walter Schroeder Hall .....

Name .....

Address .....

Confirmation will be sent as soon as possible.

Reservation Form for the Banquet and Other Events

Please check and sign in the appropriate blanks and mail to E. D. Berners, Physics Department, Marquette University, Milwaukee 3, Wisconsin.

Banquet Reservations

I expect to attend the banquet of The American Physical Society on Friday, June 19, at 7 P.M.

My party will consume ..... tenderloin dinners and ..... baked whitefish dinners.

This reservation must be received by Wednesday, June 17. Reservations accompanied by a check, made out to The American Physical Society, at $4 per person, will be held until banquet time.

Cocktail Party

I expect to attend the cocktail party on Friday, June 19, at 6 P.M. My party will include ..... persons.

Brewing Company Tours

Please reserve ..... places at the Miller Brewing Company ..... or the Schlitz Brewing Company ..... (check preference), Thursday evening, June 18.

Campus Parking

Those who have not requested parking space at Walter Schroeder Hall may reserve parking space on the Marquette campus with a check mark here .....

Name .....

Reservation Form for the Ladies' Program

I plan to attend the tea on Thursday ..... I will bring ..... children, whose ages are .....

Please reserve ..... places on the bus tour Friday, including places for ..... children, whose ages are .....

Name .....

Communication from the Treasurer

For the information of the members the Treasurer presents the following statements condensed from the report for the year 1958 of Conroy, Smith & Co., auditors, as presented to the Council at Washington on April 29, 1959.

SHIRLEY L. QUIMBY, *Treasurer*

OPERATING INCOME AND EXPENSES ALLOCABLE TO THE YEAR ENDING DECEMBER 31, 1958

Income:				
Membership dues			$211 650.22	
Net receipts from dinners and registration fees			3 714.29	
Dividends			1 679.45	
Interest on bonds and savings accounts			6 998.15	
Buckley Physics Prize Award Trust			250.00	
Miscellaneous			672.05	$224 964.16
Expenses:				
Office of the Secretary and Treasurer:				
Salaries		$ 19 211.76		
Payroll taxes and retirement fund contributions		720.88		
Traveling expenses of Officers of Society		2 561.75		
General office expenses		4 845.32	$ 27 339.71	
American Institute of Physics—collecting dues and subscriptions			$ 20 773.11	
The Physical Review:				
Income:				
Nonmember subscriptions	$132 465.28			
Published articles	163 267.40			
Sale of back numbers	6 034.31			
Membership subscriptions	68 499.56	$370 266.55		
Expenses:				
Cost of production and distribution: 7792 pages to 7526 member and 3279 nonmember subscribers	$352 643.87			
Editorial office	45 889.87	398 533.74	28 267.19	
Reviews of Modern Physics:				
Income:				
Member and nonmember subscriptions	$ 34 247.64			
Published articles	21 583.91			
Sale of back numbers	6 461.50	$ 62 293.05		
Expense:				
Cost of production and distribution: 1222 pages to 1113 member and 9168 nonmember subscribers	$ 72 338.09			
Editorial office	2 781.20	75 119.29	12 826.24	
Physical Review Letters:				
Income:				
Nonmember subscriptions	$ 139.16			
Published articles	9 860.97	$ 10 000.13		
Expense:				
Cost of production and distribution: 12 issues of approximately 11 000 copies each. Total pages—499	$ 35 685.05			
Editorial expense	23 572.72	59 257.77		
		$ 49 257.64		
Contribution—National Science Foundation		21 000.00	28 257.64	

Bulletin—Cost of printing and mailing	$ 24 799.15		
Editorial mechanics—A.I.P.	3 882.09		
	$ 28 681.24		
Deduct: Income from subscriptions	5 859.06	22 822.18	
"1958 Membership List"—printing and mailing		17 193.63	
Cost of membership and reduced rate subscriptions in excess of amounts collected therefor:			
Review of Scientific Instruments	$ 1 583.00		
Journal of Chemical Physics	4 573.00		
Journal of Applied Physics	8 596.00		
The Physics of Fluids	578.00	$ 15 330.00	
Contribution to Institution of Electrical Engineers for "*Physics Abstracts*"		38 303.00	
Contribution to American Institute of Physics for maintenance and support—10% of dues collected		20 420.02	
Miscellaneous		2 215.36	$233 748.08
Net loss from operations of 1958			$ 8 783.92

Balance Sheet as of December 31, 1958

Assets

Cash in banks:			
Checking account		$215 381.57	
Savings accounts		81 046.40	
Custodian account		762.10	$297 190.07
Accounts receivable:			
Internal Revenue Service		$ 184.16	
Teachers Insurance and Annuity Association		753.36	937.52
Investments—at cost:			
Bonds (market value $137 153.75)		$140 823.95	
Stocks (market value 107 165.75)		82 080.39	222 904.34
Deferred charges:			
Cost of membership and reduced rate subscriptions to various journals for subsequent years in excess of amounts collected therefor			12 972.00
			$534 003.93

Liabilities and Surplus

Accounts payable:			
American Institute of Physics, Inc.		$ 24 800.98	
Institution of Electrical Engineers		6 303.00	
Division of Chemical Physics		775.11	
Sundry vendors		10 143.42	$ 42 022.51
Deferred credits:			
Membership dues—years 1959 and 1960		$179 665.65	
Subscriptions received from members applicable to issues of journals to be published subsequent to December 31, 1958:			
The Physical Review	$59 903.64		
Physical Review Letters	17 839.14		
Physical Abstracts and *Electrical Engineering Abstracts*	8 527.65		
Bulletin	2 687.89	88 958.32	268 623.97
Surplus at January 1, 1958		$232 141.37	
Deduct: Net loss—year 1958		8 783.92	223 357.45
			$534 003.93

The American Physical Society

OFFICERS OF THE SOCIETY FOR 1959

President	G. E. Uhlenbeck	University of Michigan
Vice-President	V. F. Weisskopf	Massachusetts Institute of Technology
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Treasurer	S. L. Quimby	Columbia University
Managing Editor	S. A. Goudsmit	Brookhaven National Laboratory

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